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CEREAL EXPERIMENTS AT DICKINSON, N. DAK.[1]

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(In cooperation with the North Dakota Agricultural Experiment Station.)

INTRODUCTION.

The cooperative experiments with cereals at the Dickinson (N. Dak.) substation since 1907 have been confined to dry-land crops and practices. Varietal and improvement tests and cultural experiments have been conducted. The testing and improvement of cereal varieties, which have constituted the major portion of the work, are reported upon in this bulletin. The varietal tests are discussed in detail, followed by a brief statement regarding the efforts to improve those varieties which appear to be most valuable. The

[1] The Dickinson substation was established in 1905 by the North Dakota Agricultural Experiment Station and has since been operated as one of several "subexperiment stations" located at various points in the State. President J. H. Worst, of the North Dakota Agricultural College, was director of the State station from the time the Dickinson substation was established until Jan. 1, 1914, when Mr. Thomas P. Cooper was appointed director. Prof. J. H. Shepperd has been vice director of the station during the entire period. Mr. L. R. Waldron has been superintendent of the Dickinson substation except for the year 1909, when he was granted a year's leave of absence, and Mr. O. J. Grace, now superintendent of the Akron (Colo.) Experiment Farm, was acting superintendent. In 1907 cooperative cereal work was started at the Dickinson substation by the North Dakota Agricultural Experiment Station and the Bureau of Plant Industry, United States Department of Agriculture. During the first few years of this cooperation, the Bureau of Plant Industry assisted in planning and systematizing the work and in furnishing seed grain, but gave little financial aid. More recently, the entire salary of the man in charge of the cooperative work has been paid by the bureau. From 1907 to Jan. 1, 1912, the cooperative work was in direct charge successively of Supts. Waldron and Grace, Mr. Charles H. Clark, and the writer, under employment by the State. On the latter date the writer was appointed a scientific assistant in the Office of Cereal Investigations, Bureau of Plant Industry, remaining in charge of the cooperative work with cereals at Dickinson.

On July 1, 1903, a memorandum of understanding between the North Dakota Agricultural College and the Bureau of Plant Industry was accepted by both parties. This was revised on July 1, 1911. This memorandum specified that "the object of these cooperative investigations shall be (1) to improve the wheat industry in the Northern Plains region by discovering and producing varieties better than those now grown, especially with regard to nitrogen content, yield, earliness, drought resistance, etc.; (2) to conduct similar experiments with oats, barley, and other cereals when it may be desirable."

Note.—This bulletin is of interest to agronomists and cereal breeders generally, and to farmers in the northern Great Plains States.

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experiments have been conducted principally with spring varieties of wheat, oats, and barley, but some work has also been done with winter wheat and rye, spring rye, emmer, flax, proso, and grain sorghum.

The yearly reports of the cooperative cereal investigations at the Dickinson substation have been included in the annual reports of the substation[1] for the years 1908 to 1910. Most of the experiments reported upon in this bulletin were begun during that period. The work had not progressed far enough in 1910 to justify a summary of the results. With the results of seven years' experiments now available, it seems desirable to summarize them and to draw such conclusions as they appear to warrant.

DESCRIPTION OF THE SUBSTATION.

It is believed that the results obtained at the Dickinson substation are applicable to only a portion of the northern Great Plains region. That section lying west and south of the Missouri River in North Dakota and including the eastern portion of Dawson and Custer Counties in Montana has conditions very similar to those at Dickinson. The rainfall decreases southward into South Dakota and is so limited in some places that dry farming as now practiced is not profitable. A comparison of the climate of any locality in this section with that of Dickinson will aid greatly in determining to what degree the Dickinson results may be applied. In order to permit such a comparison, a detailed description of the substation is here given, together with data on the amount and distribution of rainfall and other climatological factors under which the experiments were conducted.

LOCATION.

The Dickinson substation is located 1¼ miles northwest of the city of Dickinson, near the center of Stark County, N. Dak., in the southwestern portion of the State. It comprises 160 acres, which, with the exception of one rather high butte, is gently rolling land. The elevation is approximately 2,500 feet above sea level. The topography about Dickinson is that of a broken prairie, fairly typical of western North Dakota or that part of the State west of the Missouri River which is known as the old (preglacial) landscape of North Dakota. The flat tops of the buttes and table-lands have been going through the process of erosion since before the glacial period.

During the past decade this section, comprising approximately 12,500,000 acres, has passed through a process of transformation

[1] North Dakota Agricultural Experiment Station, Dickinson Sub-Experiment Station, Annual Reports 1–3, 1908–1910.

from the open range to small farms and ranches. In 1893 it supported 3 banks; in 1903, 5 banks; and in 1913, 98 banks. This rapid growth is largely due to the great influx of settlers who have practiced general farming instead of exclusive grazing. Although there are still large tracts where, because of the roughness of the land and its consequent lack of adaptability to diversified farming, stock raising is still a dominant industry, this section now produces 8,000,000 to 10,000,000 bushels of wheat annually.

GENERAL PHYSICAL FACTORS.

A study of the crop yields for the series of years here presented necessitates some knowledge of the factors which have influenced the growth of the crop. The most important physical factors are (1) the soil; (2) the annual rainfall and its distribution; (3) the evaporation, especially that during the crop season; (4) the wind, with special reference to that which passes directly over the ground surface during the growth of the crop; and (5) the temperature, especially the spring and fall frosts which limit the growing season. These data regarding the factors recorded at the Dickinson substation are summarized herewith.

SOIL.

The soil of the Dickinson substation is reasonably typical of a large portion of the soils of the northern Great Plains region lying west and south of the Missouri River, which are mostly residual. That at Dickinson is classed in the Morton series. It varies from a clay loam to a fine sandy loam. Mechanical analyses of several samples taken from the substation show the proportion of clay to vary from 9 to 25 per cent; silt, 15 to 47 per cent; very fine sand, 13 to 29 per cent; fine sand, 10 to 31 per cent; medium sand, 1 to 11 per cent; and coarse sand, 0.5 to 3 per cent. The soils are seen to contain a considerable proportion of clay and silt, but not so much that they are difficult to work; and they would ordinarily be called light. The soil varies in depth from 8 inches to about 10 feet. The color is usually black, but in places it is quite brown and in others gray. The subsoil varies from a clay to a fine sand. Chemical analyses which have been made show the soil to be fairly fertile. The percentage of lime is considerably greater than that found in soils of more humid regions, but both it and the potash content are less than those generally found in arid and semiarid soils. The soils are deficient in humus, owing to the scanty growth of native vegetation.

NATIVE VEGETATION.

The native vegetation on this soil was principally blue grama (*Bouteloua oligostachya*), prairie June-grass (*Koeleria cristata*), Buckley's spear-grass (*Poa buckleyana*), and needle grass (*Stipa*

viridula), with occasional patches of buffalo grass (*Bulbulis dactyloides*) and western wheat-grass (*Agropyron smithii*). The grama, buffalo, and western wheat grasses supplied good grazing and have sometimes been cut for hay.

RAINFALL.

Table I contains a record of the annual precipitation at Dickinson, by months, for the years from 1892 to 1913, inclusive. The data previous to 1906 were recorded at the city of Dickinson; since that time they have been kept at the substation.

TABLE I.—*Monthly and annual precipitation at Dickinson, N. Dak., from 1892 to 1913, inclusive, with the average, maximum, and minimum for each month.*

[Rainfall in inches; T.=trace; data from the records of the Weather Bureau.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1892	[1]0.32	0.60	0.60	3.60	1.77	2.20	3.89	[1]1.50	0.10	0.24	0.15	0.38	[1]15.35
1893	.86	T.	.60	.45	2.90	1.45	1.87	.46	1.59	.37	.02	1.06	11.63
1894	.12	T.	.94	2.40	.90	4.48	3.44	.95	.90	.58	.47	.29	15.47
1895	.10	.32	1.06	1.36	1.69	3.28	2.47	.51	.13	[1].25	.34	.50	[1]12.01
1896	.92	.56	1.01	2.35	5.16	2.54	1.55	.58	.30	.71	2.65	.15	18.48
1897	1.50	1.20	2.21	1.93	.73	[1]1.19	[1]2.34	[1]1.06	.36	.15	.85	T.	[1]13.52
1898	T.	.20	.38	1.02	2.00	1.30	1.63	.77	.79	2.73	.30	.80	11.92
1899	.12	.20	.82	1.83	3.51	2.59	2.79	3.41	.08	1.43	.22	.27	17.27
1900	.21	.63	.96	.65	.48	.83	1.19	3.15	2.56	.47	.55	.10	11.78
1901	.01	.39	.70	.62	.13	3.83	3.69	.45	.83	.22	.80	1.25	12.92
1902	.18	1.43	2.64	.16	3.02	2.56	[1]3.34	[1]1.89	[1].05	[1].10	[1].40	[1].30	[1]16.07
1903	[1].85	[1].20	T.	.31	3.59	1.18	.52	5.52	3.70	.08	.13	.82	[1]16.90
1904	.33	.60	2.02	.92	.90	6.10	.32	2.68	.26	.22	.04	.80	15.19
1905	.23	.49	.15	.09	2.74	3.75	3.46	1.48	2.06	.71	1.31	.08	16.55
1906	.65	.40	.98	1.10	7.11	5.40	.16	2.64	.25	.14	.87	.76	20.46
1907	.80	.14	.39	.30	1.36	2.52	4.82	1.89	1.11	.10	.02	.22	13.67
1908	.28	.73	1.42	1.27	3.50	4.30	1.41	1.41	1.67	2.47	.78	.24	19.48
1909	.27	.52	.25	.51	5.78	3.28	1.89	5.54	.83	1.08	.29	1.02	21.26
1910	.34	.97	.82	1.71	1.26	3.02	2.07	1.61	.70	.54	.15	.15	13.34
1911	.90	.55	.43	.59	1.63	2.61	1.27	2.18	2.63	2.16	.56	.22	15.73
1912	.41	.12	.50	2.42	3.99	1.92	3.80	2.68	1.89	1.15	.18	T.	19.06
1913	.13	.04	1.22	.52	1.78	1.77	1.36	2.70	.94	1.04	.43	T.	11.93
Average	.43	.47	.92	1.19	2.54	2.82	2.24	2.05	1.08	.77	.52	.43	15.46
Maximum	1.50	1.43	2.64	3.60	7.11	6.10	4.82	5.54	3.70	2.73	2.65	1.25	21.23
Minimum	T.	T.	T.	.16	.13	.83	.16	.45	.05	.08	.02	T.	11.63

[1] Estimated from surrounding stations.

The average annual precipitation at Dickinson for the past 22 years, as shown in Table I, has been 15.46 inches. This table shows that the maximum precipitation during the 22 years from 1892 to 1913, inclusive, was 21.26 inches (in 1909) and that the minimum for the same period was 11.63 inches (in 1893). The precipitation during the year 1913 was only 0.3 inch greater than the minimum for the 22 years the records have been kept. The precipitation has been above normal 11 years and below normal 11 years. This fact is shown graphically in figure 1. Table I shows further that May, June, July, and August are the wettest months, June having the highest average rainfall, 2.82 inches. December and January are the driest months. Most of the precipitation from November to March comes in the form of snow.

The average monthly distribution of the precipitation at Dickinson is presented graphically in figure 2, which shows a gradual increase in precipitation from January to June and a gradual decrease from June to December. This distribution is very favorable to the use of crops. However, the small amount of precipitation received during the fall and winter months makes crop growth almost entirely dependent upon the precipitation which occurs during the growing

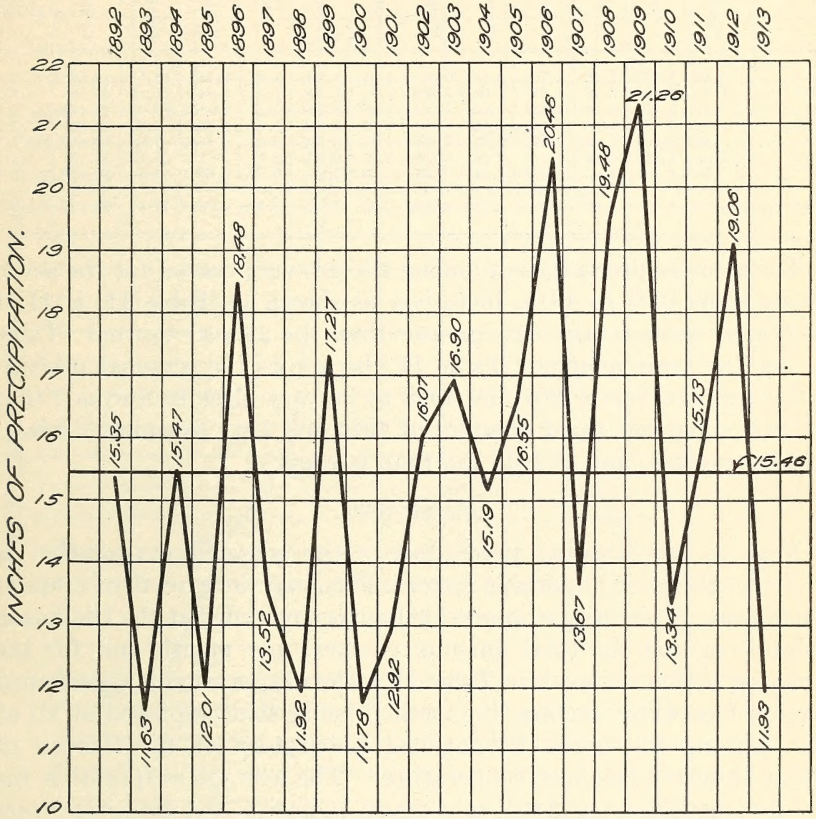


FIG. 1.—Graph showing the annual and the mean precipitation for the 22 years from 1892 to 1913, inclusive, at Dickinson, N. Dak.

season. The normal precipitation for the months of April, May, June, July, and August, the growing season at Dickinson, is 10.84 inches, or 70.1 per cent of the normal for the entire year. Should a drought period occur during the months of June and July, as was the case in 1911, a small crop is likely to result, even though the precipitation for the year is above normal. The precipitation and evaporation during the growing season for the seven years during which cooperative experiments with cereals have been conducted at the Dickinson substation are given in Table II.

TABLE II.—*Monthly precipitation and evaporation (from a free water surface) at the Dickinson substation for the crop season (April to August) of the years 1907 to 1913, inclusive.*

[Data (in inches) from the records of the Biophysical Laboratory of the Bureau of Plant Industry.]

Year.	April.		May.		June.		July.		August.		Total.		Ratio of precipitation to evaporation.
	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	
1907.....	0.30	3.200	1.38	4.765	2.68	6.019	4.82	5.886	1.93	6.755	11.11	26.625	1:2.40
1908.....	1.27	3.300	3.79	4.450	4.06	5.898	1.34	7.506	1.36	6.844	11.82	27.998	1:2.37
1909.....	.60	3.170	6.04	4.922	3.02	4.924	1.87	5.360	5.54	6.813	17.07	25.189	1:1.48
1910.....	1.71	5.420	1.26	5.187	3.03	7.097	2.35	8.678	1.48	5.665	9.83	32.047	1:3.25
1911.....	.48	5.290	1.63	5.794	2.61	7.028	1.27	9.259	1.69	5.478	7.68	32.849	1:4.28
1912.....	2.51	3.650	3.99	4.671	2.06	5.528	3.90	6.020	2.71	5.922	15.17	25.791	1:1.70
1913.....	.59	4.150	1.63	3.978	1.83	6.951	1.26	7.211	2.79	6.882	8.10	29.172	1:3.60
Average.	1.07	4.030	2.82	4.825	2.76	6.206	2.40	7.131	2.50	6.337	11.54	29.524	1:2.56

The average precipitation during the growing season for the seven years from 1907 to 1913, inclusive, as shown in Table II, is 11.54 inches, or seven-tenths inch greater than the 22-year normal (Table I) for the same months. Table II also shows the seasonal precipitation for the years 1907 and 1908 to be very close to normal; that of 1909 about one-third greater; of 1910 and 1911 considerably less; of 1912 greater; and of 1913 less than normal.

EVAPORATION.

Next to the seasonal precipitation, the seasonal evaporation is probably the most important factor influencing the growth of crops at Dickinson. The daily evaporation has been recorded at the Dickinson substation, and the total amount (inches) per month and for the growing season is shown in Table II. The evaporation is determined from a free water surface, the method being that employed at all of the stations where the Biophysical Laboratory of the Bureau of Plant Industry has been cooperating.[1] The average evaporation for the five months from April to August, inclusive, for the seven years from 1907 to 1913 was 29.524 inches. The lowest total evaporation—25.189 inches—was recorded in 1909, the year of the greatest rainfall. The largest total evaporation—32.849 inches—was recorded in 1911, the year of the lowest seasonal rainfall. Thus the amount of evaporation usually varies inversely with the amount of precipitation.

The ratio of precipitation to evaporation, also given in Table II, shows the evaporation for the seven years to be 2.56 times the precipitation. In 1909 the ratio was the narrowest, the evaporation for that year being only 1.48 times the precipitation. In 1911 the ratio was the widest, when the evaporation was 4.28 times the precipita-

[1] Briggs, L. J., and Belz, J. O. Dry farming in relation to rainfall and evaporation. U. S. Dept. Agr., Bur. Plant Indus. Bul. 188, p. 16–20, 1910.

tion. These ratios for the different years compared with the average ratio for the entire period offer an excellent basis for judging the seasonal conditions under which the experiments reported in this bulletin were conducted.

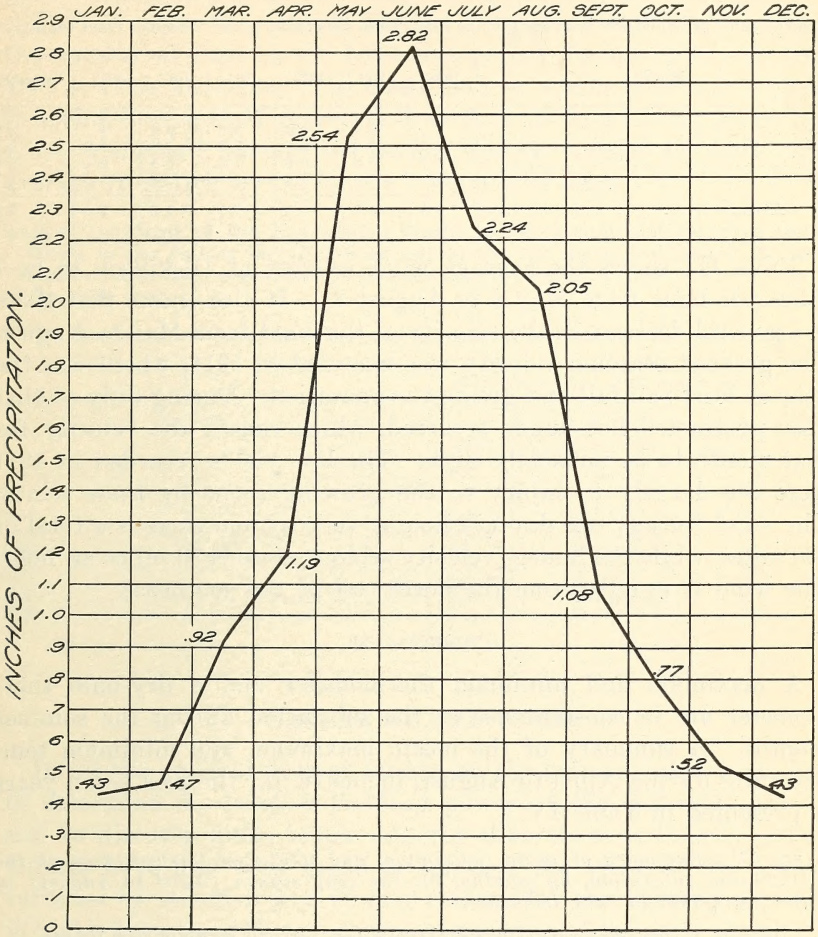


FIG. 2.—Graph showing the average monthly precipitation for the 22 years from 1892 to 1913, inclusive, at Dickinson, N. Dak.

WIND.

The anemometer used at the Dickinson substation was not obtained until June, 1908, and for that reason the records of the wind for 1907 and for May, 1908, are not available. Complete records for April were not taken except for the years 1912 and 1913, when the averages were 8.4 and 9.4 miles, respectively. Since June, 1908, a complete record of the wind during four months of the growing season has been kept. The anemometer stands next to the evaporation tank at a height of about 2 feet from the surface of the ground.

The average wind velocities in miles per hour during the months from May to August for the years 1908 to 1913, inclusive, are presented in Table III.

TABLE III.—*Average wind velocity at the Dickinson substation, by months, from May to August for the years 1908 to 1913, inclusive.*

[Data (in miles per hour) from the records of the Biophysical Laboratory of the Bureau of Plant Industry.]

Month.	1908	1909	1910	1911	1912	1913	Average.
May	.....	9.4	8.0	9.6	9.6	8.1	8.9
June	8.9	7.0	6.7	7.3	6.6	7.9	7.4
July	4.9	5.6	6.1	7.5	5.6	6.4	6.0
August	5.9	4.9	5.4	6.4	7.1	5.5	5.8
Average	6.6	6.7	6.6	7.7	7.2	7.0	7.0

Table III shows the average wind velocity at Dickinson to be 7 miles per hour from May 1 to August 31. It also shows that there is a general decrease in the velocity of the wind from May to August. The greatest seasonal velocity was recorded in 1911, which was the year of least rainfall and greatest evaporation. During July of that year protracted hot winds occurred, which caused the velocity for that month to be unusually high. The low yields recorded in 1911 were due largely to injury to the growing crops by these winds. The wind for any one day (24 hours) very seldom exceeds a total of 500 miles, while the hourly velocity seldom exceeds 30 miles an hour. The wind is usually from the northwest or the southeast.

TEMPERATURE.

A maximum and minimum thermometer and a dry-bulb thermometer are in constant use at the substation during the summer months. A summary of the mean, maximum, and minimum temperatures during April to August, inclusive, for the past seven years is presented in Table IV.

TABLE IV.—*Summary of mean, maximum, and minimum temperatures at the Dickinson substation, by months, for the crop season (April to August) of the years 1907 to 1913, inclusive.*

[Data (in °F.) from the records of the Biophysical Laboratory of the Bureau of Plant Industry.]

Year.	April.			May.			June.			July.			August.			Seasonal mean.
	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	
1907	35	69	5	43	74	11	56	86	30	64	93	44	64	97	34	52
1908	43	88	−6	49	74	20	59	88	37	70	97	40	64	100	27	58
1909	34	62	4	51	86	20	62	94	41	67	93	46	68	94	38	56
1910	49	89	18	50	80	24	64	97	29	69	107	41	61	97	33	59
1911	39	87	6	52	86	23	65	97	41	66	101	37	60	95	28	56
1912	44	75	16	52	82	32	61	97	32	65	91	36	64	87	41	57
1913	46	85	19	50	92	24	63	97	35	65	96	40	69	97	42	59
Average	31	79	9	50	82	22	60	93	35	67	97	41	64	95	35	57

Table IV shows that the highest average mean, maximum, and minimum temperatures have been recorded in July, and that in this month alone frost has not occurred. This table also shows that the average mean temperature for the different seasons varied but little from the 7-year average of 57° F.

Table V gives the dates of the last spring and first fall frosts and the number of days in the frost-free period during each year from 1907 to 1913, inclusive. The latest date on which frost has occurred in spring during the 7 years was June 5, in 1910 and 1912; the earliest frost in the fall during this period was on August 19, 1907. The average frost-free period for the 7 years is 99 days.

TABLE V.—*Dates of the last killing frosts in the spring and the first killing frosts in the fall at the Dickinson substation for the years 1907 to 1913, inclusive; also the temperatures recorded and the length of the frost-free period for each year.*

[Data from the records of the Biophysical Laboratory of the Bureau of Plant Industry.]

Year.	Last frost in spring.		First frost in fall.		Frost-free period.
	Date.	Temperature.	Date.	Temperature.	
		° F.		° F.	*Days.*
1907	June 4	30	Aug. 19	34	76
1908	May 21	29	Aug. 21	27	92
1909	May 17	32	Sept. 14	34	120
1910	June 5	29	Sept. 8	28	95
1911	May 27	27	Aug. 27	28	92
1912	June 5	32	Sept. 21	32	108
1913	May 21	32	Sept. 10	30	112
Average	May 28	.....	Sept. 4	.....	99

NATURE OF THE WORK.

In all the varietal tests at Dickinson the primary object has been to determine the relative yielding power of the different varieties and to discover kinds better adapted than those ordinarily grown. Efforts have also been made to improve the yield of the leading varieties by selection and to find reasons for the existing variation in yields between different groups of varieties of the same cereal. In order to make these studies complete, it was necessary to divide the work into plat and nursery experiments. The plat experiments were designed to conform as nearly as possible to the best farm practices in the northern Great Plains region. On these plats the crops were studied on an extensive scale. In the nursery tests, which were confined to short rows, the crops were studied intensively. The rows were uniformly spaced and a weighed quantity of seed was planted in each row. This method made possible the testing of a large number of varieties and offered a means of making a study of a considerable number of plants of each variety.

CONDITIONS OF THE PLAT EXPERIMENTS.

DIMENSIONS OF THE PLATS.

Most of the field tests were conducted on tenth-acre plats. These plats are mostly 24 feet wide by 181.5 feet long, though a few are 33 feet wide and 132 feet long. In some years, on account of lack of space or seed, the plats were one-twentieth acre in size, measuring 12 by 181.5 feet or 16.5 by 132 feet. The plats lay side by side in series, which extend both north and south and east and west. They are separated within the series by 3-foot alleys, while the series are separated by 16.5-foot roads. Each plat is thus bounded on the sides by a 3-foot alley and on the ends by a 16.5 foot road. A general view of the plats is shown in figure 3.

FIG. 3.—General view of the varietal plats of cereals at the Dickinson substation in 1910.

TREATMENT OF THE PLATS.

For the first year's planting the land had been broken from virgin soil the previous spring and backset or else worked down well with disk and harrow and kept free from weeds throughout the season. The following spring most of the land was double disked and harrowed. In all cases, sufficient spring cultivation was given to put the land in good tilth and keep down the weeds. The treatment of the plats for each succeeding year is given in the discussion of each crop. Cultivated crops (corn or potatoes) are grown in alternate years on the plats used for the experiments with cereals. This system gives nearly as good results as would be given by a system of alternate cropping and fallowing, and much better results than continuous cropping to cereals. For the cultivated crop the land is spring plowed to a depth of about 8 inches, disked, and harrowed. The plats are harrowed at least once after planting to corn or potatoes, and frequent cultivations are given during the season, thus keeping them free from weeds. After removing the crop in the fall the land is usually harrowed.

The plats are prepared for seeding to the cereals by double disking and harrowing. The seeding is done with a 6-foot single-disk drill. The disks are 6 inches apart, with a covering chain attached to each disk. The seed is sown as uniformly as possible at what is considered the best rate and covered to a depth of 2 to 3 inches. Before seeding, it is treated for smut with a solution containing 1 pound of formaldehyde to 40 gallons of water. The wheat is sown as soon as the land can be put in proper tilth in the spring, which is nearly always possible by the middle of April. Oats and barley are usually sown a week or ten days later.

When the plants are about 6 inches high, the plats are usually cultivated across the drill rows with a spring-tooth weeder. This implement is very efficient in breaking the crust and is less severe on the young plants than the spike-tooth harrow. No further cultivation is given. The plats are rogued each year in order to keep the varieties as free as possible from mixtures. The harvesting is done with a binder. The bundles are shocked and allowed to stand on the fields for two to four weeks before they are thrashed.

CHECK PLATS.

Check plats for determining the comparative or computed yields of the varieties have been used since 1908 in the varietal tests of wheat and since 1909 in those of oats and barley. These check plats, which are distributed through a series, are sown to the same variety and given identical treatment. In the series of wheat varieties, two check plats were sown in 1908 and three in 1909. The results indicated that a greater number of check plats should be used if any value was to be attached to the computed yields obtained by their use. In 1910 the practice of planting every fifth plat to the same variety as a check was adopted, and since that time this method has been in use for all the varietal tests of wheat, oats, and barley.

It was believed that the difference in yield of these check plats would show the variation of the soil throughout the series and that their average yield would equal the average yield of the variety used if it had been grown on the entire series. Then, by knowing the plat yield of a variety, its average yield per acre in terms of the check variety could be computed with reasonable accuracy. From the yield of the check plats distributed through the series, the rates of increase or decrease were computed for all plats. This difference was added to the actual yield of the varieties or subtracted from it, as the case might be. A different method, which is considered better, was used in 1912 and 1913. After obtaining the actual yield of all plats and the average yield of all checks, a graduated yield was figured for all plats from the yield of the different checks. The actual yield is then divided by the graduated yield and the

quotient is multiplied by the average yield of all check plats. The two methods are more clearly shown in the following equations:

FIRST METHOD.	SECOND METHOD.
$x=a+(b-y)$.	$x=a \div y \times b$, or $ab \div y$.

Wherein, a=actual yield of variety.
b=average yield of all check plats.
x=computed yield of variety.
y=assumed yield of check.

The check system as used at Dickinson has proved to be only fairly satisfactory. It affords a means of gaining a better idea of the relative yielding power of several varieties during certain seasons than would have been the case had no system designed for that purpose been used. In other seasons, however, the yields of the various check plats were influenced by so many uncontrollable factors (moisture, weeds, etc.) that to assume that any one of the other varieties would be affected by the same cause and to a like degree would be more of a theory than a determination. Usually the yields of the check plats were quite uniform; however, they sometimes varied as much as 50 to 100 per cent. A variety grown on a plat next to a high-yielding check plat will have a computed yield less than its actual yield. If next to a low-yielding check plat, the computed yield of the variety will exceed its actual yield. When the yield of a check plat is unusually high or low, the computed yield of varieties grown on adjacent plats are unusually and sometimes unreasonably low or high. Such instances cause one to accept with caution results based on computed yields alone. It is thought that actual yields of a variety for a period of several years, especially when the variety is shifted to several different places on the farm, are fairly dependable. For these reasons and because computed yields are not available for all years, the conclusions in this bulletin are based principally on the actual yields. The computed yields for those years in which they were determined are given for the purpose of comparison.

VARIETAL TESTS.

The plat tests have included a large number of varieties and strains of cereals imported from various parts of the world. Many of these were introduced during the early years of the work and have since been discarded. Those varieties which appeared to be best adapted to the conditions of western North Dakota in regard to yield, growth habits, utility, etc., have been continued in the trials, which have included 53 varieties and strains of spring wheat, 38 of spring oats, 16 of spring barleys, and a number of varieties of winter wheat and rye, spring rye, and emmer. With some of these cereals the duration of the trials is too short to be conclusive, while with others some very satisfactory results have been obtained.

Rather complete data are taken upon the behavior of the different varieties. The quantity of grain actually sown upon the plat is determined by weighing the grain placed in the drill and that taken out after the plat is seeded. The difference in the two weighings is the actual quantity of grain sown. After the plants emerge and when it is certain no more will appear, the number of thousand plants to the acre is determined for each variety.[1] Notes on the date of planting, emergence, heading, ripening, and harvesting each variety are also taken. At harvest time a small but representative sample of the grain from each plat is pulled and taken to the laboratory for further study.

A small separator with an 18-inch cylinder is used in thrashing. The total weight of the crop and the weight of the thrashed grain from each plat are obtained. The weighings are made at the thrashing machine, one just before and the other immediately after the grain is thrashed. If the separator does not deliver the grain free from chaff and dirt, it is cleaned and reweighed. The weight of the grain is subtracted from the total weight of the crop, to determine the weight of the straw and chaff. The weight of grain and the weight of straw per plat are multiplied by the proper factor, to determine the yield in pounds per acre. The weight of grain divided by the standard weight per bushel of the crop gives the actual yield of grain to the acre. In the laboratory a study is made of the sample of grain taken from each plat. The percentage of rust infection, if any, is noted. The average height, head length, culms per plant, heads per plant, and grains per head of 10 plants from each plat are recorded. Small samples of grain of a portion of the wheat varieties are sent to the North Dakota Agricultural College, where milling and baking tests are made.

WHEAT.

It is well known that the northern Great Plains area is primarily a spring-wheat region. Practically no winter wheat is grown in western North Dakota. Farmers have many times planted small areas to winter wheat only to have it killed during the winter or spring by freezing. The varietal tests of this crop at Dickinson have been confined almost entirely to the spring wheats.

Spring Wheat.

The annual and average yields in bushels per acre obtained in varietal tests with spring wheat at Dickinson from 1907 to 1913 are given in Table VI. The 1912 crop was entirely destroyed by hail; hence, the results of only six years are given. Check plats have been used since 1908.

[1] For an explanation of the method used in making these determinations, see p. 22.

TABLE VI.—*Actual (annual and average) yields of 53 varieties of wheat grown at the Dickinson substation, 1907 to 1913, inclusive.*[1]

C. I. No.[2]	Variety.	Actual yield per acre (bushels).							Number of years grown.
		1907	1908	1909	1910	1911	1913	Average.	
1440	Kubanka	36	23.5	33.7	14.9	3.8	26.7	23.1	6
1517	Ghirka Spring	22.6	23.5	[3] 28.9	28.6	[3] 9.5	[4] 26.6	23.3	6
3022	Rysting Fife	17.6	22.3	33	20.7	7.7	28.1	21.6	6
3314	Crossbred Bluestem (N. Dak. No. 318)	18.7	22.3	30.5	14.3	6.9	27.1	20	6
1350	Pererodka	28.4	18.8	36	23			26.6	4
1444	Yellow Gharnovka	28.6	17.6	33.7	15.1			23.8	4
1493	Arnautka (Wild Goose)	28.4	24	36.5	15.7			26.2	4
1494	Arnautka	26.4	22.8	37	23.4			27.4	4
1584	Pelissier	21.5	24	30.1	23.4			24.8	4
2006	Nicaragua	27.9	22.3	38.2	18.2			26.7	4
2088	Kahla	31.5	[5] 19.8	34.8				28.7	3
3020	Haynes Bluestem (Minn. No. 169)	14	21.4	30	([6])			21.8	3
2959	Gatineau	19.4	19.5					19.5	2
1445	Velvet Don	26.8							1
1446	Black Don	27							1
1447	Gharnovka	26.3							1
1520	Beloturka	29.8							1
1570	Tagenrog	25.7							1
1597	Medeah	23.8							1
1736	Iumillo	24.4							1
3011	Haynes Bluestem	17.2							1
3023	Bolton Bluestem	17.6			([6])				1
3025	Power Fife	15.3							1
	American Bluestem	15.8			([6])				1
1566	Fretes		19.5	24.5				22	2
2398	Galgalos		20.7	23				21.9	2
3035	Mexican No. 1		22.1	26.5				24.3	2
3036	Mexican No. 2		19.5						1
4063	Kubanka No. 8			43.2	[7] 19.9	3.5	31.2	24.5	4
3313	Bowman			31.7	19.1	10		20.3	3
4065	Kubanka No. 9			29	19.8			24.4	2
3081	Bearded Fife				23	[5] 9.7	25.2	19.4	3
2949	Summer				18.9				1
2953	Yakutsk				18				1
3709	Jerusalem				16.7				1
3710	do				21				1
	Coffee				20.7				1
	Polish				14.1				1
2874	Haynes Bluestem (Minn. No. 169)					8.6	24.8	16.7	2
3315	Huron					13.7	26.9	20.3	2
3316	Pringle Champlain					6.4	24.8	15.6	2
3319	White Fife					8.6	24.8	16.7	2
3320	Durum No. 1					[8] 16.7	30.9	23.8	2
3321	Durum No. 4					[8] 15.7	28.5	22.1	2
3322	Durum No. 5					[8] 15.8	28	21.9	2
3323	Durum No. 7					[8] 16.7	25.8	21.3	2
3328	Preston					9.2	26.2	17.7	2
3329	Red Fife					6.4	28.3	17.4	2
3317	Riga					7.3			1
3318	Bearded Fife (Velvet Chaff)						27.8		1
3641	Marquis						24.2		1
4064	Arnautka 6P1						30.9		1
2492	Manchuria						18.1		1
	Average	23.8	21.5	32.2	19.4	8.0	26.8	22.0	

[1] The 1912 crop was entirely destroyed by hail; hence, this year is not included.
[2] Cereal investigations number.
[3] Average of 3 plats.
[4] Average of 4 plats.
[5] Average of 2 plats.
[6] Destroyed by hail.
[7] Average of 6 plats.
[8] Not comparable with other yields for 1911.

The annual and average computed yields of the varieties based on the check yields are given in Table VII, with the average actual yield for comparison. The difference in the actual and computed yields may be considered in part as the probable experimental error due to the variation of the soil. During the six years 53 varieties or strains of wheat have been tested. In 1913 only 20 of the 53 varieties or strains were grown, 33 having been discarded. Of these 20 only 4 have been grown during the entire period. The varieties are ar-

ranged in the table according to the year of their introduction into the tests.

TABLE VII.—*Computed (annual and average) yields of 40 varieties of wheat at the Dickinson substation, 1908 to 1913, inclusive, compared with the average actual yield for the same years.*

C. I. No.	Variety.	Yield per acre (bushels).						
		1908	1909	1910	1911	1913	Average.	
							Computed.	Actual.
1440	Kubanka	23.2	31.9	18.7	3.8	27.9	25.4	24.7
1517	Ghirka Spring	23.5	28.9	27.3	9.5	26.6	23.2	23.4
3022	Rysting Fife	23.5	33.4	21.6	9	28.1	23.1	22.4
3314	Crossbred Bluestem (N. Dak. No. 318)	22.3	30.9	11	7.6	28	20	20.2
1350	Pererodka	17.8	34.5	22.4			24.9	25.9
1444	Yellow Gharnovka	16.5	33.9	17.9			22.8	22.1
1493	Arnautka (Wild Goose)	23.4	35	17.6			25.3	25.4
1494	Arnautka	22.4	36	22.4			26.9	27.7
1584	Pelissier	23.4	29.6	23			25.3	25.8
2006	Nicaragua	21.1	37.9	19.3			26.1	26.2
2088	Kahla	20.5	33.6				27.1	27.9
3020	Haynes Bluestem (Minn. No. 169)	22.3	30.5				26.4	25.7
2959	Gatineau	19.4						
1596	Fretes	19.6	25.3				22.5	22
2398	Galgalos	21	23.7				22.5	21.9
3035	Mexican No. 1	22.5	27.1				24.8	24.3
3036	Mexican No. 2	20.1						
4063	Kubanka No. 8		42.5	19.9	3.5	31.7	31.4	31.4
3313	Bowman		22.6	18.3	11		17.3	20.3
4065	Kubanka No. 9		30	19.7			24.9	24.4
3081	Bearded Fife			21.7	9.9	24.4	18.7	19.2
2949	Summer			18.7				
2953	Yakutsk			18.3				
3709	Jerusalem			24.4				
3710	do			20.5				
	Coffee			23.6				
	Polish			16.6				
2874	Haynes Bluestem (Minn. No. 169)				9.6	26	17.8	16.7
3315	Huron				14.8	26	20.4	20.3
3316	Pringle Champlain				7.5	23.8	15.7	15.6
3319	White Fife				10.2	24.6	17.4	16.7
3328	Preston				9.2	25.5	17.4	17.7
3329	Red Fife				5.4	27.8	16.6	17.4
3317	Riga				6.3			
3320	Durum No. 1					29.8		
3321	Durum No. 4					26.6		
3322	Durum No. 5					26.9		
3323	Durum No. 7					26.5		
3318	Bearded Fife (Velvet Chaff)					26.7		
3641	Marquis					24.5		
4064	Arnautka 6P1					30.6		
2492	Manchuria					19.6		

In 1907, 1908, and 1909 the wheat was grown on new land which had been broken and backset the previous season. In succeeding years this crop usually followed potatoes, though some of the varieties were grown after corn in 1910 and 1911. The seed has ordinarily been sown about April 15; in 1910, however, the date of seeding was March 29. Except in 1911, when about half the varieties were sown March 25 and the remainder about a month later, all varieties have been sown on the same date. In 1907 the common wheat was drilled at the rate of 5 pecks and the durum varieties at the rate of 6 pecks to the acre. These rates have been reduced gradually, until in 1913 all varieties were sown at the rate of 50 pounds ($3\frac{1}{3}$ pecks) to the acre. The size of the plats has usually been one-tenth or one-eleventh of an acre.

Table VI shows that the average yield in bushels per acre for all varieties of spring wheat tested at Dickinson in 1907 was 23.8; in 1908, 21.5; in 1909, 32.3; in 1910, 19.4; in 1911, 8; and in 1913, 26.8. The average yield of all varieties for the six years was 22 bushels per acre. A comparison of the annual yields with the annual rainfall shows that moisture is the principal factor in determining yield.

SUMMARY OF WHEAT YIELDS.

In summing up the yields for all years, the leading varieties of each group of wheat were selected. Their actual and computed annual and average yields are given in Table VIII. They are representative varieties, improved by selection and the careful cleaning and grading of the seed. There are two great groups of spring wheat—the durum and the common. The varieties of spring common wheat grown in the North-Central States may be divided into three groups—fife, bearded fife, and bluestem. At Dickinson the durum, fife, bearded fife, and bluestem varieties rank in yield in the order named. The average actual yield for six years (1907 to 1911 and 1913) of the two leading durum varieties (Kubanka and Arnautka) is 11.5 per cent greater than the average yield of the two leading fife varieties (Ghirka Spring and Rysting) and 29.4 per cent greater than the average yield of the two leading bluestem varieties (Crossbred and Haynes). There is little difference in the yield of the fife and bearded fife varieties.

TABLE VIII.—*Actual and computed (annual and average) yields of seven standard varieties of spring wheat grown at the Dickinson substation from 1907 to 1913, inclusive.*

[The groups and varieties are arranged according to their actual and computed average yields.]

C. I. No.	Group and variety.	Yield per acre (bushels).								
								Average.		
		1907	1908	1909	1910	1911	1913	6 years, 1907 to 1911 and 1913.	5 years, 1908 to 1911 and 1913.	3 years, 1910, 1911, and 1913.
	ACTUAL YIELDS.									
	Durum:									
1440	Kubanka [1]	36.0	23.5	43.2	19.9	3.5	31.2	26.2	24.3	18.2
1494	Arnautka [2]	26.4	22.8	37	23.4	[3] 3.2	30.9	24	23.5	19.2
	Fife:									
1517	Ghirka spring	22.6	23.5	28.9	28.6	9.5	26.6	23.3	23.4	21.6
3022	Rysting	17.6	22.3	33	20.7	7.7	28.1	21.6	22.4	18.8
	Bearded fife:									
3081	Bearded Fife	.....	.....	.....	23	9.7	25.6	.....	.....	19.4
	Bluestem:									
3314	Crossbred (N. Dak. No. 318)	18.7	22.3	30.5	14.3	6.9	27.1	20	20.2	16.1
3020	Haynes (Minn. No. 169) [4]	14	21.4	30	[5] 13.1	8.6	24.8	18.7	19.6	15.5

[1] For 1907 and 1908, Kubanka (C. I. No. 1440); for 1909 to 1913, Kubanka No. 8 (C. I. No. 4063), a pure-line selection from C. I. No. 1440 made at Dickinson, N. Dak.

[2] For 1907 to 1910, Arnautka (C. I. No. 1494); for 1913, Arnautka 6P1 (C. I. No. 4046), a pure-line selection from C. I. No. 1494 made at Akron, Colo.

[3] Estimated from yield of Kubanka (C. I. No. 1440).

[4] For 1907 to 1909, Haynes Bluestem (C. I. No. 3020); for 1911 and 1913, Haynes Bluestem (C. I. No. 2870). These two lots of seed were from the same original source, the Minnesota Agricultural Experiment Station.

[5] Estimated from yield of Crossbred (C. I. No. 3314).

TABLE VIII.—*Actual and computed (annual and average) yields of seven standard varieties of spring wheat, etc.*—Continued.

C. I. No.	Group and variety.	Yield per acre (bushels).								
								Average.		
		1907	1908	1909	1910	1911	1913	6 years, 1907 to 1911 and 1913.	5 years, 1908 to 1911 and 1913.	3 years, 1910, 1911, and 1913.
	COMPUTED YIELDS.									
	Durum:									
1440	Kubanka [1]	.....	23.2	42.5	19.9	3.5	31.7	.....	24.2	18.4
1494	Arnautka [2]	.....	22.4	36	22.4	[3] 3.3	30.6	.....	22.9	18.8
	Fife:									
1517	Ghirka Spring	.....	23.5	28.9	27.3	9.5	26.6	.....	23.2	21.1
3022	Rysting	.....	23.5	33.4	21.6	9	28.1	.....	23.1	19.6
	Bearded fife:									
3081	Bearded Fife	.....	.....	.....	21.7	9.9	24.4	.....	.....	18.7
	Bluestem:									
3314	Crossbred (N. Dak. No. 318)	.....	22.3	30.9	11	7.6	28	.....	20	15.5
3020	Haynes (Minn. No. 169) [4]	.....	22.3	30.5	[5] 10.9	9.6	26	.....	19.9	15.2

[1] For 1907 and 1908, Kubanka (C. I. No. 1440); for 1909 to 1913, Kubanka No. 8 (C. I. No. 4063), a pure-line selection from C. I. No. 1440 made at Dickinson, N. Dak.
[2] For 1907 to 1910, Arnautka (C. I. No. 1494); for 1913, Arnautka 6P1 (C. I. No. 4046), a pure-line selection from C. I. No. 1494 made at Akron, Colo.
[3] Estimated from yield of Kukanka (C. I. No. 1440).
[4] For 1907 to 1909, Haynes Bluestem (C. I. No. 3020); for 1911 and 1913, Haynes Bluestem (C. I. No. 2870). These two lots of seed were from the same original source the Minnesota Agricultural Experiment Station.
[5] Estimated from yield of Crossbred (C. I. No. 3314)

Of all the varieties tested, a few of outstanding merit should be more widely known. With a full knowledge of each of the leading varieties, the individual farmer can decide which he prefers to grow. He can then, by careful cleaning and grading of the seed, maintain the quality of his crop and keep it above the average.

THE DURUM GROUP.

The Kubanka and Arnautka have proved to be the best of more than 20 varieties of durum wheat tested at Dickinson. These varieties are very similar in appearance. Both have long yellowish beards, smooth yellow chaff, and very hard, clear amber grain.[1]

Kubanka.—The Kubanka (C. I. No. 1440) is considered the best durum wheat for western North Dakota. The plants are taller than the spring common wheats. The heads are short and broad (fig. 4) and the grains large. This wheat was introduced into the United States from Russia in 1899 by Mr. M. A. Carleton, Cerealist of the United States Department of Agriculture. In the tests at Dickinson it has been one of the leading varieties nearly every year. Its superiority over other durum wheats was early recognized, and a number of pure-line selections were made in 1906 by Mr. L. R. Waldron. One of these, Kubanka No. 8 (C. I. No. 4063), has proved

[1] For a more complete discussion of durum wheat, see Salmon, Cecil, and Clark, J. A., Durum wheat, U. S. Dept. Agr., Farmers' Bul. 534, 16 p., 4 fig., 1913.

to be superior to the original strain. The yields obtained from this pure line are substituted for those of the original strain in Table VIII, and the average yield is therefore greater than that of the original stock shown in Tables VI and VII. Both C. I. No. 1440 and C. I. No. 4063 have good milling qualities, but the volume of the loaf is comparatively small. (See Pl. I.)

Arnautka.—The variety Arnautka (C. I. No. 1494) is typical of the durum wheat most commonly grown in North Dakota and South Dakota. It is better adapted to the eastern portion of these States. Arnautka is slightly taller than Kubanka, with longer, more slender heads (fig. 4) and longer grain. It originally came from Russia, where it is grown in the more humid territory bordering on

FIG. 4.—Heads of eight varieties of wheat grown at the Dickinson substation: Durum group—(1) Kubanka No. 8 and (2) Arnautka 6P1; bearded fife group—(3) Bearded Fife; fife group—(4) Ghirka, (5) Rysting, and (6) Marquis; and bluestem group—(7) Crossbred and (8) Haynes.

the Sea of Azof. The stock grown at Dickinson was obtained by the United States Department of Agriculture from Mr. T. N. Oium, Lisbon, N. Dak., in 1900. It has often been called Goose wheat or Wild Goose. The Arnautka wheat has yielded well in our trials, but is exceeded in yield by the Kubanka. A pure-line selection from Arnautka, Arnautka 6P1 (C. I. No. 4064), made at the Akron (Colo.) Experiment Farm has yielded better than the original variety and has been substituted for it in our trials. In milling quality the Arnautka is inferior to the Kubanka.

THE FIFE GROUP.

Among the varieties of the fife group which have been tested at Dickinson the Ghirka Spring and the Rysting have given the best

yields. The Red Fife and Marquis are promising varieties which have recently been introduced into the trials at Dickinson. The appearance of these varieties is similar in many ways. They are beardless, with smooth, white glumes and dark-red kernels.

Ghirka.—The Ghirka wheat (C. I. No. 1517) differs from the other varieties in the fife group in that it has longer and lighter colored kernels and the grain is not so hard. The heads of this wheat (fig. 4) are tapering, while those of other varieties of the group are more blunt. The leaves of the young growing plants are of a bluish green shade and the culm at the base of the head is tinged with purple. This wheat was obtained by the United States Department of Agriculture at the Paris Exposition in 1900. Its original source was Grodno Province in western Russia. Many other importations of this variety of wheat have evidently been made by Russian immigrants, as there are thousands of acres of it grown in western North Dakota as "Russian" wheat. In our trials through a series of years, the Ghirka wheat has outyielded all other varieties of common wheat. During the drier years it has yielded best. In years of more abundant rainfall, when wheat diseases are apt to be prevalent, the Ghirka suffers. This variety is inferior in milling quality to the other fife wheats. Breeding work was commenced with Ghirka wheat in 1910, when 300 head selections were made. A brief statement of the work already done toward improving the yield and the milling qualities of this variety is included in the discussion of nursery experiments.

Red Fife.—The Red Fife wheat (C. I. No. 3329) originated about 60 years ago, being a chance discovery by Mr. David Fife, of Ontonabee, Ontario.[1] It is the typical fife wheat which is grown generally throughout the spring-wheat area. The plants have a normal height of 33 to 36 inches. The head, which is fairly compact and broad, is borne quite erect on the strong straw. The glumes are very firm, short, and drawn together at the point, which prevents shattering. The grain is of fine quality, short, broad, and very plump. By the careful selection and grading of this wheat a high standard of quality has been maintained. From it many strains and varieties have been originated. Among the principal varieties are the Glyndon Fife (Minn. No. 163), Power Fife, and Rysting Fife. These wheats have often been known collectively as Scotch Fife. During the two years the Red Fife has been grown in our trials it has yielded about the same as the Rysting, but the milling and baking tests have shown it to be superior in quality.

Marquis.—The Marquis wheat (C. I. No. 3641) was originated from a cross made by Dr. A. P. Saunders in 1892 between an early-ripen-

[1] Saunders, William. Review of the work with wheat at the experimental farms. *In* Canada Dept. Agr., Exp. Farms, Rpt. 1903, p. 13, 1904.

ing Indian wheat (Hard Red Calcutta) and Red Fife. One of the varieties isolated from the progeny by Dr. C. E. Saunders, cerealist of the Central Experimental Farm at Ottawa, Canada, was named Marquis. This was first grown as a pure line in 1904. The plants are slightly shorter than the Red Fife, as are also the heads (fig. 4). The spikelets are more nearly square at the base and the grain is shorter and plumper. Experimental trials in Canada showed it to be especially well adapted to Saskatchewan, and its early ripening habits gave it an immense advantage over other varieties. Milling and baking tests showed that the flour was of excellent color and that it had high bread-making strength. Seed of this variety has been increased rapidly and distributed widely. It was first introduced into the trials at Dickinson in 1912, but the crop was destroyed by hail. In 1913 another lot of seed was obtained from the experimental farm at Lethbridge, Alberta. It yielded about 4 bushels per acre less than Red Fife. Milling and baking tests showed that it ranked first in color, fourth in loaf volume, eleventh in yield of straight flour, and thirteenth in percentage of crude protein in the wheat when compared with 15 other samples of common wheats.

THE BEARDED-FIFE GROUP.

All of the varieties in the bearded fife group included in the trials at Dickinson have been tested for only a short period. The leading varieties are Bearded Fife (C. I. No. 3081), Huron (C. I. No. 3315), and Preston (C. I. No. 3328). They are quite similar in appearance, all being bearded, with dark-red kernels. The chaff of Huron is light brown, while that of the others is white. They are known commercially in the hard spring-wheat district as "velvet chaff." This term, however, is wrongly applied, as the chaff is smooth.

Bearded Fife.—The Bearded or "Red" Fife wheat (C. I. No. 3081) has yielded next to the Ghirka during the three years, 1910, 1911, and 1913, in which yields have been obtained. The plants are shorter than the common fife wheats, as are also the heads, which have wide spreading awns (fig. 4) and glumes more open at the point. The Bearded Fife ripens earlier than the durum and bluestem wheats, but later than the Marquis and Ghirka. The origin of this variety is unknown. The stock used in the trial at Dickinson was obtained from the Dakota Improved Seed Co., of Mitchell, S. Dak. Milling and baking tests for a period of three years show it to possess good bread-making qualities.

Huron.—The Huron wheat (C. I. No. 3315) during a 2-year trial has yielded better than the Bearded Fife. It is slightly taller and earlier than that variety. The Huron was originated by Dr. A. P.

Saunders from a cross made in 1888 between the Ladoga and Red Fife. The stock of this variety, as well as that of the Red Fife, Preston, and Pringle Champlain, was obtained from the experimental farm at Brandon, Manitoba.

Preston.—The Preston wheat (C. I. No. 3328) has yielded as well as the Bearded Fife during the two years tested. It is very similar to the Huron. This wheat also was originated by Dr. Saunders from a cross between Ladoga and White Fife. It was first mentioned in the report of the Canadian Experimental Farms for 1893, since which time it has become a standard variety in Canada.

THE BLUESTEM GROUP.

Two varieties of the bluestem group, Crossbred (N. Dak. No. 318) and Haynes (Minn. No. 169), have been included in the trials at Dickinson. These varieties are quite similar in appearance, both being beardless, with white, hairy chaff and dark-red kernels.

Haynes Bluestem.—The strain of Haynes Bluestem wheat known as Minnesota No. 169 (C. I. No. 3020) was originated by the Minnesota Agricultural Experiment Station. It is a selection made in 1893 from Haynes Bluestem (Minn. No. 51). Two lots of seed of this variety were used in the trials at Dickinson, the first lot having been lost by hail. The variety is late in maturing, and for this reason it is not well adapted to the conditions at Dickinson. In only one year out of six has it outyielded the standard fife and durum varieties. It has, however, superior bread-making qualities.

Crossbred Bluestem.—The strain of bluestem wheat known as Crossbred Bluestem (N. Dak. No. 318, C. I. Nos. 3314 and 3695) was originated by Prof. W. M. Hays, of the North Dakota Agricultural Experiment Station, in 1893, from an incross between two plants of Glyndon 753, a bluestem wheat grown by the Minnesota Agricultural Experiment Station and represented by its Nos. 116, 157, and 478. It is shorter than the Haynes Bluestem and exceeds it slightly in yield, but can not be distinguished by its appearance from other bluestem wheats. It is more commonly grown in eastern North Dakota and is well adapted to that part of the State.

As seen in Table VIII, the yield of the bluestem wheats is low, and their growth in western North Dakota should be discouraged rather than encouraged.

MISCELLANEOUS DATA.

In making comparisons of different varieties of spring wheat, other data than the grain yields are important. Table IX shows the comparative behavior during the growing season of the varieties included in Table VIII.

TABLE IX.—*Average miscellaneous data for seven varieties of wheat grown at the Dickinson substation for periods of 3 to 6 years (1907 to 1913).*

[Superior index figures indicate the number of years during which the data were obtained when this number is less than the number of years in which the variety was grown.]

C. I. No.	Group and variety.	Number of years grown.	Average date—		Average time to maturity from—		Average height.	Average stand (plants per acre).	Average actual yield per acre.		Average weight per bushel.
			Headed.	Ripe.	Planting.	Heading.			Grain.	Straw.	
	Durum:				*Days.*	*Days.*	*In.*		*Bu.*	*Cwt.*	*Lbs.*
1440	Kubanka	6	July 7	Aug. 13	125	37	39	[3]380,000	26.2	21.1	62
1494	Arnautka	5	July 8	Aug. 16	125	39	[4]42	[2]390,000	28.1	22.7	61
	Fife:										
1517	Ghirka	6	July 6	Aug. 8	120	31	34	[3]420,000	23.3	[5]17.3	60
3022	Rysting	6	July 13	Aug. 11	123	29	[5]35	[3]563,000	21.6	[4]17.8	57
3081	Bearded Fife	3	July 2	Aug. 1	121	30	30	[3]477,000	19.4	20.3	61
	Bluestem:										
3314	Crossbred (N. Dak. No. 318)	6	July 14	Aug. 13	125	30	33	[2]550,000	20.0	[5]16.4	58
3020	Haynes (Minn. No. 169)	5	July 13	Aug. 15	124	33	36	[2]470,000	19.8	[3]16.4	57

The stand, as used in Table IX, means the number of plants to the acre. This is determined shortly after emergence by counting the number of plants contained in a metal frame inclosing $\frac{1}{4000}$ of an acre. Four counts are made to the plat, the total actual count being the number of plants on $\frac{1}{1000}$ of an acre, or, conversely, the number of thousands of plants per acre. Several factors, such as the size of the grain and the viability of the seed, influence the stand. There seems to be no definite correlation between stand and yield within the limits of 300,000 to 600,000 plants per acre.

Spring wheat is usually headed at Dickinson by the middle of July and is ripe by the middle of August. Of the varieties included in Table IX, the Ghirka and Bearded Fife are the first to mature. The Marquis, a beardless fife, was the earliest maturing variety in 1913. This is an important factor for drought-resistant or drought-escaping cereals. The durum varieties head earlier than the ordinary fife and bluestem varieties, but require a longer period from heading to maturity and ripen at about the same time.

The straw yields of the bearded fife varieties are less than those of the durums, but more than those of the beardless fifes and bluestems. The same statement may be made with regard to the weight of grain per bushel. The average height of the spring wheats at Dickinson is about 3 feet. The height of the durum varieties is greater than the average, while that of the bearded fife varieties is a trifle less. The average length of head is about 3 inches. The heads of the durum and bearded fife varieties are usually shorter than the average, while those of the fife and bluestem varieties are usually longer. The head length of the varieties within each group varies: for instance, the heads of the Arnautka average con-

siderably longer than those of the Kubanka. Figure 4 shows the heads of some of the more important varieties. The average number of heads to the plant produced by the different varieties is two, with an average of 25 kernels each.

MILLING AND BAKING TESTS.

Although for four years milling and baking tests have been made from grain of the wheat varieties grown at Dickinson, the same size of mill was used only two years—1911 and 1913—and the results for the other two years are not directly comparable. The more important data from the milling tests for 1911 and 1913 are given in Table X. This table shows the yield of straight flour and the volume of loaf baked from the flour of several varieties of bluestem, durum, bearded fife, and fife wheats, together with the yield of grain per acre. The groups and varieties are arranged according to their average yields of straight flour.

TABLE X.—*Annual and average yields, percentages of straight flour, and volumes of loaves obtained from 15 varieties of wheat grown at the Dickinson, N. Dak., substation in 1911 and 1913.*

[The groups and varieties are arranged according to their average yields of straight flour.]

C. I. No.	Group and variety.	Yield per acre (bushels).			Yield of straight flour (per cent).			Volume of loaf (cubic centimeters).		
		1911	1913	Average.	1911	1913	Average.	1911	1913	Average.
	Bluestem:									
3314	Crossbred (N. Dak. No. 318)	6.9	27.1	17	72.5	73.1	72.8	2,320	2,213	2,267
3020	Haynes (Minn. No. 169)	8.6	24.8	16.7	73.5	71.2	72.4	2,320	2,260	2,290
	Durum:									
4063	Kubanka No. 8	3.5	31.2	17.4	75.1	72.7	73.9	1,950	1,995	1,973
1440	Kubanka	3.8	26.7	15.3	71.2	71.8	71.5	1,970	1,985	1,978
4064	Arnautka 6 P1	.....	30.9	.....	.....	60.7	.....	.....	1,980	.....
	Bearded fife:									
3315	Huron	13.7	26.9	20.3	72.9	72	72.5	2,080	1,970	2,025
3081	Bearded Fife	9.7	25.6	17.7	71.9	70.7	71.3	2,275	2,170	2,223
3316	Pringles Champlain	6.4	24.8	15.6	71.5	70.5	71	2,150	2,030	2,090
3328	Preston	9.2	26.2	17.7	70.1	68.9	69	2,080	2,020	2,055
3318	Bearded Fife (Velvet Chaff)	.....	27.8	.....	.....	66.6	.....	.....	2,135	.....
	Fife:									
3329	Red Fife	6.4	28.3	17.4	73.8	71.8	72.8	2,150	2,220	2,185
3319	White Fife	8.6	24.8	16.7	72.8	71.6	72.2	2,400	2,340	2,370
3022	Rysting	7.7	28.1	17.9	71.2	70.6	70.9	2,060	2,000	2,030
1517	Ghirka	9.5	26.6	18.1	68.7	65.3	67	2,150	2,270	2,210
3641	Marquis	.....	24.2	.....	.....	69.2	.....	.....	2,250	.....
	SUMMARY OF GROUPS.									
	Bluestem	7.75	25.95	16.85	73	72.15	72.58	2,320	2,237	2,278
	Durum	3.65	29.6	16.63	73.15	71.4	72.28	1,960	1,987	1,973
	Bearded fife	9.75	26.26	18	71.6	69.74	70.67	2,146	2,065	2,106
	Fife	8.05	26.4	17.23	71.62	69.7	70.66	2,190	2,216	2,203

The bluestem group averaged the greatest percentage of flour, with the durums a close second. The bearded fife and fife varieties averaged practically the same, the yield being considerably less than that of the bluestems. The durum variety Kubanka No. 8 gave the highest average percentage of flour for any one variety, 73.9 per cent. Bakings, which were made in duplicate from these flours, showed the volume of the loaf of the bluestem varieties to be the largest, that

of the fife varieties next largest, with the bearded fife, and durums following in the order named. The fife variety White Fife (C. I. No. 3319) gave the greatest average volume (2,370 c. c.) to the loaf. The volume of the loaf, as well as the texture and other important factors, are shown in cross sections of these loaves of bread in Plate I. The average volume of loaf of four varieties of fife wheat in 1911 was 2 per cent greater than that of four varieties of bearded fife wheat. In 1913 five varieties of fife wheat gave a loaf volume 7 per cent greater than five varieties of bearded fife wheat. An average for the two years gives a gain of 4.5 per cent in favor of fife wheat. The average yield of straight flour for the two classes of wheat was practically the same.

Winter Wheat.

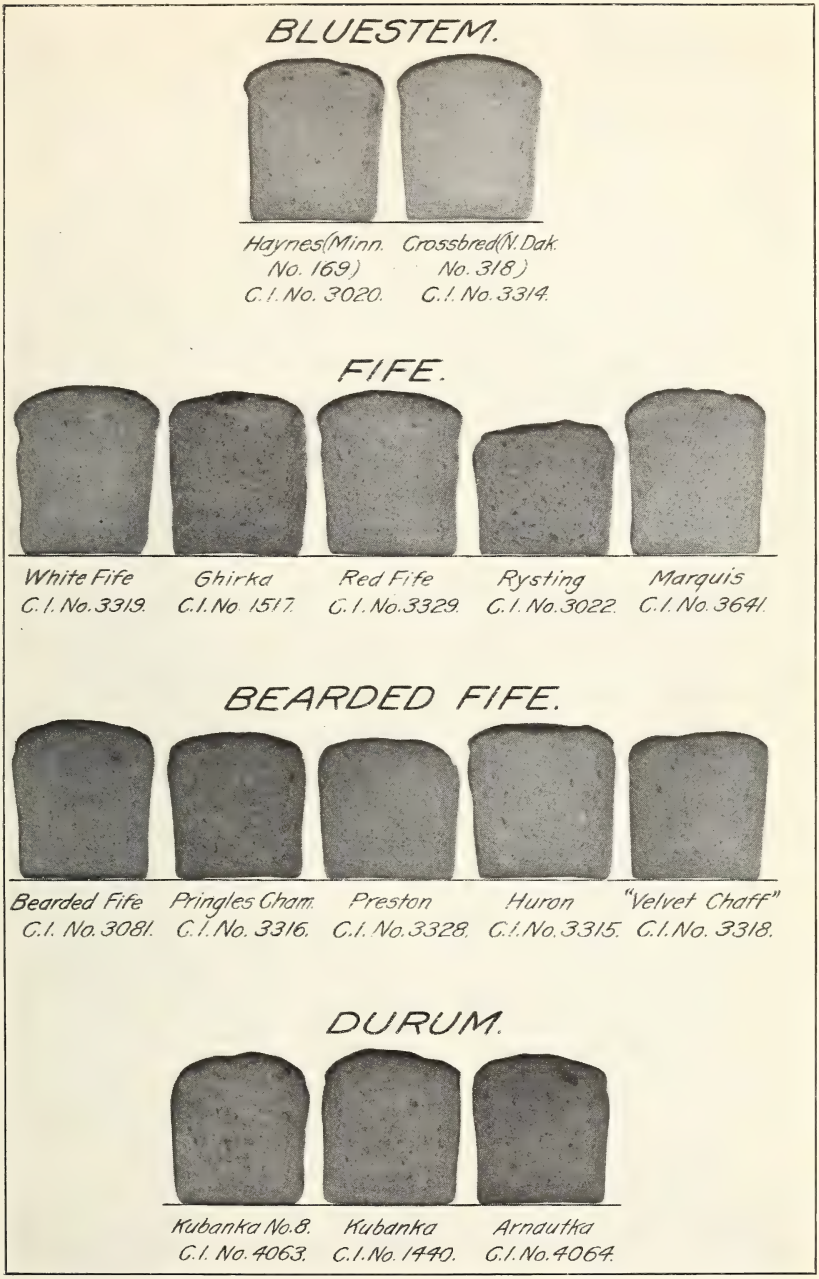
Varietal tests with winter wheat were started in the fall of 1912. The results of only one year are therefore available. The trial included five varieties. Plantings were made in duplicate, one set being planted on fallowed land, the other on corn land with the cornstalks left standing. An average yield of 13.5 bushels per acre was obtained from the varieties planted on corn land and 4.7 bushels per acre from the same varieties planted on fallowed land. The standing cornstalks caught the drifting snow during the winter, which resulted in giving a measure of protection to the wheat plants. Stand notes of plants per acre taken in the fall shortly after emergence, and again in the spring after the surviving plants had made some growth, showed an average survival for all varieties on the corn land to be 33 per cent and on fallowed land 19 per cent.

The varieties yielded according to their percentage of survival. The variety having the greatest survival was North Dakota No. 1997 (C. I. No. 3084), a bearded variety of the Turkey type. The next most hardy variety was Beloglina (C. I. No. 1543), with Kharkof (C. I. No. 1583) and Turkey (C. I. No. 1571) following in the order named. Turkey wheat, which has been under trial for several years at Dickinson, has given indifferent results, the stand in all seasons being greatly reduced by winterkilling. Many different cultural methods have been used in an attempt to find a method of producing a profitable crop of winter wheat. In all cases either total or severe winterkilling has resulted.

It is evident that North Dakota will continue to grow spring rather than winter wheat until different cultural methods from any now advocated are used or until hardier varieties or strains of winter wheat than any yet known are produced.

OATS.

The actual acre yields obtained from trials with 38 varieties of oats grown at Dickinson from 1907 to 1913 are presented in Table



CROSS SECTIONS OF LOAVES OF BREAD MADE FROM 15 VARIETIES OF SPRING WHEAT GROWN AT THE DICKINSON EXPERIMENT SUBSTATION IN 1913.

The grain was milled and the bread baked at the North Dakota Agricultural College.

XI. During four years of this period, 1909, 1911, 1912, and 1913, computed yields were figured from the use of check plats. These computed yields are given in Table XII, with average actual yields for comparison.

The oats were sown in 1907, 1908, and 1909 on new land that had been broken the previous season and before seeding had been worked down well with the disk and spike-tooth harrows. In 1910 and succeeding years this crop was sown on spring-disked land on which corn had been grown the preceding year. The seed was sown about April 20 except in 1912, when seeding was delayed till May 7. The usual rate of seeding has been 6 pecks to the acre. The worked down well with the disk and spike-tooth harrows. In 1910 the later varieties were destroyed by hail. On July 11, 1912, the oats were severely injured by hail, but all varieties produced good yields of seed from the second growth except the White Russian, which did not mature.

TABLE XI.—*Actual (annual and average) yields of 38 varieties of oats grown at the Dickinson substation, 1907 to 1913, inclusive.*

C. I. No.	Variety.	Actual yield per acre (bushels).								Number of years grown.
		1907	1908	1909	1910	1911	1912	1913	Average.	
134	Swedish Select	46.9	.....	81.3	38.1	5.6	[1] 52.3	61.9	47.7	6
160	Banner	46.8	41.6	89.4	[2]	6.2	65	48.1	49.5	6
165	Sixty-Day	58.2	37.2	.....	45	22.8	42.2	42.2	41.3	6
459	Kherson	75.3	48.1	81.3	46.2	16.7	50.9	45	51.9	7
493	Golden Rain	35.2	52.8	[1] 82.2	35.6	14.4	62.8	70.9	50.6	7
551	White Russian	62.8	28.1	64.3	[2]	14.3	[2]	53.4	44.6	5
754	Early Mountain	80.9	36.8	90	43.7	3.8	.....	.....	51	5
386	.....	79	47.5	79.8	[2]	2.8	.....	.....	52.3	4
492	Ligowo	36	37.5	75.3	[2] 36.6	.....	.....	.....	46.4	4
344	.....	56.9	34.5	73.3	.....	.....	.....	.....	54.9	3
354	.....	70	42	77.8	[2]	.....	.....	.....	63.3	3
366	Black Brie	68.1	40.8	81.5	[2]	.....	.....	.....	63.5	3
368	Canadian	81.2	33.3	71.6	[2]	.....	.....	.....	62	3
376	Heine Prolific	63.1	40.2	75	[2]	.....	.....	.....	59.8	3
378	Beseler No. 1	63.1	32	69.7	[2]	.....	.....	.....	54.9	3
445	White Tartarian	72.8	33.9	83.1	[2]	.....	.....	.....	63.3	3
483	Shatilovsky	23.1	44.1	82.6	[2]	.....	.....	.....	49.9	3
491	Hvitling	42.6	39.2	73.5	[2]	.....	.....	.....	51.8	3
496	Black Bell	47.8	36.6	40	.....	.....	.....	.....	41.5	3
497	Black Mogul	50.9	46.6	77.8	[2]	.....	.....	.....	58.4	3
495	White Probsteier	35.5	.....	76.5	[2]	.....	.....	.....	56	2
360	Black	70	40.3	.....	.....	.....	.....	.....	55.2	2
370	.....	54	41.3	.....	.....	.....	.....	.....	47.7	2
135	Tobolsk	44.1	.....	.....	.....	.....	.....	.....	.....	1
156	Columbus	39.2	.....	.....	.....	.....	.....	.....	.....	1
162	American Triumph	42.1	.....	.....	.....	.....	.....	.....	.....	1
163	American Beauty	48.4	.....	.....	.....	.....	.....	.....	.....	1
336	Belyak	42.6	.....	.....	.....	.....	.....	.....	.....	1
481	.....	50.6	.....	.....	.....	.....	.....	.....	.....	1
486	.....	40.4	.....	.....	.....	.....	.....	.....	.....	1
494	Awnless Probsteier	44.4	.....	.....	.....	.....	.....	.....	.....	1
560	Victory	.....	42.5	88.3	[2]	8.9	59.4	70.6	53.9	5
658	Big Four	.....	35.3	84.7	[2]	7.9	60.2	65.6	50.5	5
552	Regenerated Swedish Select	.....	35.6	73.6	[2]	.....	.....	.....	54.6	2
659	Silvermine	.....	.....	64.1	[2]	8.1	55.8	66.9	48.7	4
621	National	.....	.....	57.2	[2]	.....	.....	.....	.....	1
170	Perm	.....	.....	.....	[2]	18	53.6	45	38.9	3
656	Early Mountain No. 2	.....	.....	.....	[2]	[3] 11.3	58.6	[4] 67.3	45.7	3
	Average	53.6	39.5	75.8	40.5	10.8	56.1	57.9	47.7	

[1] Average of 4 check plats.
[2] Destroyed by hail.
[3] Average of 5 check plats.
[4] Average of 6 check plats.

Table XI shows that the average actual yield per acre of all varieties of oats grown in 1907 was 53.6 bushels; in 1908, 39.5 bushels; in 1909, 75.8 bushels; in 1910, 40.5 bushels; in 1911, 10.8 bushels; in 1912, 56.1 bushels; and in 1913, 57.9 bushels. The average of these averages for the seven years was 47.7 bushels. The variations in the average yields for the different years, due to the physical conditions, are about in the same proportion as were those in the average yields of the spring-wheat varieties. The cultural methods used were practically the same.

TABLE XII.—*Computed (annual and average) yields of 26 varieties of oats at the Dickinson substation, 1909 to 1913, inclusive,*[1] *compared with the average actual yield for the same years.*

C. I. No.	Variety.	Yield per acre (bushels).					
		1909	1911	1912	1913	Average.	
						Computed.	Actual.
134	Swedish Select	81.3	9.8	52.3	68.7	53	50.3
160	Banner	87.9	8.2	63.1	47.8	51.8	52.2
165	Sixty-Day	.....	23.1	45.4	47.8	38.8	35.7
459	Kherson	80.7	16.4	55.3	52.7	51.3	48.5
493	Golden Rain	86.3	11.2	62.2	69.7	57.4	58
551	White Russian	80.9	13.3	.....	53.5	49.2	44
754	Early Mountain	88.5	7.6	.....	.....	48.1	46.9
386	.....	80.6	6.9	.....	.....	43.8	41.3
492	Ligowo	77	.....	.....	.....	.....	.....
344	.....	73.6	.....	.....	.....	.....	.....
354	.....	79.2	.....	.....	.....	.....	.....
366	Black Brie	80	.....	.....	.....	.....	.....
368	Canadian	71.8	.....	.....	.....	.....	.....
376	Heine Prolific	76.2	.....	.....	.....	.....	.....
378	Beseler No. 1	70.5	.....	.....	.....	.....	.....
445	White Tartarian	81.6	.....	.....	.....	.....	.....
483	Shatilovsky	82.6	.....	.....	.....	.....	.....
491	Hvitling	75.6	.....	.....	.....	.....	.....
496	Black Bell	56.6	.....	.....	.....	.....	.....
497	Black Mogul	79.7	.....	.....	.....	.....	.....
495	White Probsteier	75	.....	.....	.....	.....	.....
560	Victory	87.3	3.1	60.3	71.3	55.5	56.8
658	Big Four	84.2	12.3	59.6	63.9	55	54.6
552	Regenerated Swedish Select	75.6	.....	.....	.....	.....	.....
659	Silvermine	63.9	7.6	53.9	70.4	49	48.7
170	Perm	.....	19	56.3	55.5	43.6	38.9
656	Early Mountain No. 2	.....	11.3	58.7	67.3	45.8	45.7

[1] The check plats of the 1910 crop were destroyed by hail; therefore no computed yields are given for that year.

SUMMARY OF OAT YIELDS.

The actual and computed annual and average yields of the leading varieties of each group of oats are given in Table XIII. Four groups of oats—medium early, medium late, early, and late—are represented, ranking in yield in the order named. The average actual yield for the seven years from 1907 to 1913 for the two leading medium-early varieties is 12.5 per cent greater than the average actual yield of the two leading early varieties. For the five years 1908, 1909, and 1911 to 1913, the average actual yield of the leading medium-early variety is 13 per cent greater than that of the medium-late variety, 17 per cent greater than that of the leading early

variety, and 36.5 per cent greater than that of the late one. The same relative relation exists between the leading varieties of the different groups for the four years 1909, 1911, 1912, and 1913, when both the actual and computed yields can be compared.

TABLE XIII.—*Actual and computed (annual and average) yields of nine standard varieties of oats grown at the Dickinson substation, 1907 to 1913, inclusive.*

[The groups and varieties are arranged according to their actual and computed average yields.]

C. I. No.	Group and variety.	Yield per acre (bushels).									
									Average.		
		1907	1908	1909	1910	1911	1912	1913	7 years, 1907 to 1913.	5 years, 1908 and 1909, 1911 to 1913.	4 years, 1909, 1911 to 1913.
	ACTUAL YIELDS.										
	Medium early:										
656	Early Mountain [1]	80.9	36.8	90	43.7	11.3	58.6	67.3	54.1	52.8	56.8
493	Golden Rain	35.2	52.8	82.2	35.6	14.4	62.8	70.9	50.6	56.6	57.6
560	Victory	.....	42.5	88.3	.....	8.9	59.4	70.6	.....	53.9	56.8
658	Big Four	.....	35.3	84.7	.....	7.9	60.2	65.6	.....	50.7	54.6
134	Swedish Select	46.9	[2] 40.7	81.3	38.1	5.6	52.3	61.9	46.8	48.4	50.3
	Medium late:										
160	Banner	46.8	41.6	89.4	.....	6.2	65	48.1	.....	50.1	52.2
	Early:										
459	Kherson	73.5	48.1	81.3	46.2	16.7	50.9	45	51.9	48.4	48.5
165	Sixty-Day	58.2	37.2	[2] 73.6	45	22.8	42.2	42.2	45.8	43.3	45.2
	Late:										
551	White Russian	62.8	28.1	64.3	.....	14.3	[2] 47.5	53.4	.....	41.5	44.9
	COMPUTED YIELDS.										
	Medium early:										
493	Golden Rain	.....	.....	86.3	.....	11.2	62.2	69.7	.....	.....	57.4
656	Early Mountain [1]	.....	.....	88.5	.....	11.3	58.7	67.3	.....	.....	56.5
560	Victory	.....	.....	87.3	.....	3.1	60.3	71.3	.....	.....	55.5
658	Big Four	.....	.....	84.2	.....	12.3	59.6	63.9	.....	.....	55
134	Swedish Select	.....	.....	81.3	.....	9.8	52.3	68.7	.....	.....	53
	Medium late:										
160	Banner	.....	.....	87.9	.....	8.2	63.1	47.8	.....	.....	51.8
	Early:										
459	Kherson	.....	.....	80.7	.....	16.4	55.3	52.7	.....	.....	51.3
165	Sixty-Day	.....	.....	[2] 73.4	.....	23.1	45.4	47.8	.....	.....	47.4
	Late:										
551	White Russian	.....	.....	80.9	.....	13.3	[2] 53.7	53.5	.....	.....	50.4

[1] For 1907 to 1910, Early Mountain (C. I. No. 754); for 1911 to 1913, Early Mountain No. 2 (C. I. No. 656).
[2] Estimated from yields of the Early Mountain, Golden Rain, and Kherson varieties.

LEADING VARIETIES.

Of all the varieties tested, a few which have proved to be best adapted should be more generally grown. A knowledge of the characteristics of the leading varieties will enable the farmer to decide which is best for him to grow. There is a wide range in the time of maturity of the different varieties of oats, thus enabling the grower to choose the one which best fits into his farm practice.

THE MEDIUM-EARLY GROUP.

Of more than 30 varieties of medium-early oats which have been tested at Dickinson, the Early Mountain, Golden Rain, and Victory have so far proved superior.

Early Mountain.—The Early Mountain oat (C. I. No. 754) was obtained by the Dickinson substation from Oscar H. Will & Co., Bismarck, N. Dak.[1] It has been under trial at Dickinson for seven years, during which time it has nearly always been one of the leading oats in yield. Several pure-line selections were made from this variety by Mr. L. R. Waldron in 1908, one of which, Early Mountain No. 2 (C. I. No. 656), proved superior and was substituted for the original stock in the varietal trials. It has given the highest average yield of all varieties under trial for the 7-year period 1907 to 1913; the third highest yield of all varieties tested in the five years 1908, 1909, and 1911 to 1913; and the second highest actual and com-

FIG. 5.—Heads of four varieties of oats grown at the Dickinson substation: From left to right—(1) Early Mountain No. 2, (2) Victory, (3) Kherson, and (4) White Russian.

puted yields for the 4-year period 1909 and 1911 to 1913. It is considered one of the best yielding oats for western North Dakota. It has a broad-spreading open panicle (fig. 5). The spikelets, which are usually 2-grained, are small and short. The fairly large white grain is awnless or only occasionally awned.

Golden Rain.—The Golden Rain oat (C. I. No. 493) is one of a number of varieties obtained from the Swedish Plant-Breeding Association, Svalof, Sweden, by the United States Department of Agriculture in March, 1907. It has been under trial at Dickinson for seven years. With the exception of the first year after introduction

[1] The Early Mountain oat was "imported a few years ago from the Castle Farm, Oberroslau, Unterroslau, Bavaria, and grown by Mr. John Yegen, near Bismarck, N. Dak." Will & Co., Oscar H. Annual Seed Catalog, 1914, p. 58.

it has always been one of the best yielding oats. For the seven years from 1907 to 1913, it ranks third in yield. It is first of all varieties in yield for the five years 1908, 1909, 1911, 1912, and 1913, with an average of 56.6 bushels. For the four years 1909, 1911, 1912, and 1913, it is first in both actual and computed yield. This variety of oats should be better known and more widely grown. It succeeds on a great variety of soils. The straw is fine, but very strong. The panicle, though small, has numerous dense, erect branches. The kernels are golden, not especially attractive in appearance, but give the highest average weight per bushel of all varieties tested.

Victory.—The Victory oat (C. I. No. 560) was obtained in 1908 from the same source as the Golden Rain. Like that variety it is a pure line, having been developed from a single plant. It is the leading white oat at Svalof. It has been on trial six years at Dickinson, but the crop one year was destroyed by hail. For the five years in which yields have been recorded it ranks next to the Golden Rain, with an average yield of 2.7 bushels less than that variety. For the four years 1909 and 1911 to 1913, it has equaled the actual yield of the Early Mountain, but falls slightly below that variety in computed yield. The straw is perhaps stiffer than the Golden Rain, and it can therefore be grown on richer land without lodging. The panicle is rather small, but dense, with stiff branches. (Fig. 5.) The grain is white, of medium size, short and broad, and only occasionally awned.

THE MEDIUM-LATE GROUP.

Only one medium-late variety has been continued in the trials at Dickinson. This variety, Banner (C. I. No. 160), requires about a week longer to mature than the medium-early varieties. It is an old and well-known variety and is typical of the oats generally grown in the State. The stock used in the trial was obtained from the experimental farm at Indian Head, Saskatchewan. The yields have been slightly above the average of all varieties tested. While it has yielded slightly more than the early varieties, it should not be recommended in preference to them, as its later maturity makes it more susceptible to loss by hail, drought, frost, etc.

THE EARLY GROUP.

Early-maturing oats have yielded well at Dickinson, especially in the drier years. The most promising varieties of this group are the Kherson (C. I. No. 459) and the Sixty-Day (C. I. No. 165).[1] These varieties are very similar in appearance, having short, slender straw, small, open panicles (fig. 5), and small, slender, yellowish white, awnless grain. Both varieties were obtained from southern Russia,

[1] For a full discussion of the Sixty-Day and Kherson varieties of oats, see Warburton, C. W., "Sixty-Day and Kherson oats," U. S. Dept. Agr., Farmers' Bul. 395, 27 p., 5 figs., 1910.

the Kherson by the Nebraska Agricultural Experiment Station and the Sixty-Day by the United States Department of Agriculture. The Kherson, as shown in Table XIII, has outyielded the Sixty-Day in all years except one, and for the 7-year period from 1907 to 1913 has exceeded it in yield by over 13 per cent.

THE LATE GROUP.

Late varieties of oats are not well adapted to western North Dakota. When not damaged by hail, drought, or frost, they yield fairly well. Those who wish their oats to mature after the wheat crop is harvested may prefer to grow the later varieties. One variety, the White Russian (C. I. No. 551), has been continued in the trial at Dickinson. The original seed was obtained from the North Dakota Agricultural Experiment Station at Fargo. It is a tall oat, producing a heavy, rank growth. The panicle is large, long, and one sided. (Fig. 5.) The grain is white, long, but well filled and plump. Unless late oats best fit the system of management on the individual farm, their growth should be discouraged in western North Dakota.

MISCELLANEOUS DATA ON OATS.

Some of the more significant data on the varieties of oats included in Table XIII are given in Table XIV. This table shows the comparative behavior of the different varieties during the growing season, as well as the yield of straw, weight per bushel, height, etc., which are important factors to be considered in making a comparison between different varieties.

TABLE XIV.—*Average miscellaneous data for nine varieties of oats grown at the Dickinson substation for periods of three to six years (1907 to 1913).*

[Superior index figures indicate the number of years in which the data were obtained when this number is less than the number of years in which the variety was grown.]

C. I. No.	Group and variety.	Number of years grown.	Growth factors (data for 1912 not included). Average date—Headed.	Average date—Ripe.	Average time to maturity from—Planting.	Average time to maturity from—Heading.	Average height.	Average stand (plants per acre).	Average actual yield per acre—Grain.	Average actual yield per acre—Straw.	Average weight per bushel.
	Medium early:				*Days.*	*Days.*	*In.*		*Bu.*	*Cwt.*	*Lbs.*
656	Early Mountain.	7	July 10	Aug. 13	117	34	34	[4]542,000	54.1	[6]24.6	34.8
495	Golden Rain.....	7	July 11	...do.....	115	33	37	[4]512,000	50.8	[5]25.4	37.8
530	Victory.....	5	July 12	...do.....	117	32	37	[3]460,000	53.9	[4]24.6	37.3
658	Big Four.....	5	July 11	...do.....	117	33	34	[3]449,000	50.7	[4]23.0	35.6
134	Swedish Select..	6	July 9	Aug. 12	116	33	[5]36	[4]512,000	47.4	[5]21.1	34.5
	Medium late:										
160	Banner.....	6	July 14	Aug. 19	123	36	35	[3]422,000	49.5	[5]27.5	34.6
	Early:										
459	Kherson.....	7	July 2	Aug. 1	104	30	29	[4]545,000	51.9	[6]19.0	33.6
165	Sixty-Day.....	6	July 1	July 31	103	30	27	[4]649,000	41.3	[5]16.3	33.4
	Late:										
551	White Russian..	5	July 17	Aug. 24	128	38	36	[2]443,000	44.6	23.5	36.9

Table XIV shows that the early varieties, the Kherson and Sixty-Day, matured in about 103 days after planting. The medium-early varieties, such as the Early Mountain and Victory, mature in about 117 days, the medium-late variety, Banner, in 123 days, and the late variety, White Russian, in 128 days. The average date of heading for the medium-early varieties is July 11 and the average date of ripening August 13. The early varieties mature about two weeks earlier and the medium-late and late varieties 6 and 11 days later, respectively. The time of maturing is an important feature to be considered with the oat crop. Early varieties often escape climatic conditions, such as hail and hot winds, that seriously injure later varieties.

The average height of the early varieties is about 28 inches, which gives sufficient length of straw for binding. The average height of the other varieties is about 36 inches. Stand notes which have been taken for a number of years show no definite correlation with yield between the different varieties. The early varieties yield less straw than the later ones; hence, the latter are to be preferred when the straw is to be used for feed. The earlier varieties also usually weigh less to the measured bushel. The medium-early varieties, however, yield well in straw and the weight per bushel is high.

BARLEY.

The varietal trials of barley have been conducted in much the same manner as those of wheat and oats. In 1907 and 1908 the barley varieties were grown on new land which had been broken the previous year. In 1909 and in succeeding years they were grown on corn land disked just previous to seeding. The usual date of seeding has been about April 20, though in 1912 the seed was not sown till May 8. The rate of seeding has varied from 8 pecks to the acre in 1907 and 1908 to 5 pecks in 1912 and 1913. In 1912 the second growth, which was produced after the hailstorm of July 11, matured seed, but only four varieties were thrashed because of lack of help.

The actual acre yields obtained from 16 varieties grown at Dickinson from 1907 to 1913 are presented in Table XV.

TABLE XV.—*Actual (annual and average) yields of 16 varieties of barley grown at the Dickinson substation, 1907 to 1913, inclusive.*

C. I. No.	Variety.	Actual yield per acre (bushels).								Number of years grown.
		1907	1908	1909	1910	1911	1912	1913	Average.	
203	Hanna	46.8	28.5	39.8	34.8	17	46	31.4	34.9	7
262	Nepal [1]	40.9	22.1	24.1	23	8.4	(2)	20.9	23.3	6
575	Gatami	36.7	31.4	27.9	34.5	11.9	(2)	27.5	28.3	6
863	Manchuria	16.5	27.9	30.2	28	7.8	(2)	30.6	23.5	6
289	Imperial	34.7	28.3	40.4	.....	.....	.....	.....	34.5	3
187	Svanhals	.....	39.4	44.9	[3]34.8	8.2	(2)	41.1	33.7	5

[1] For comparison, the yields of the naked varieties are given in bushels of 48 pounds. The actual yield in bushels of 60 pounds, the standard weight, would be one-fifth less.

[2] Yields not recorded.

[3] Average of 4 check plats.

TABLE XV.—*Actual (annual and average) yields of 16 varieties of barley grown at the Dickinson substation, 1907 to 1913, inclusive*—Continued.

C. I. No.	Variety.	Actual yield per acre (bushels).								Number of years grown.
		1907	1908	1909	1910	1911	1912	1913	Average.	
531	Hannchen	.....	37.5	[1] 48.7	35.4	[1] 15.2	39.2	[1] 35	35.2	6
532	Primus	.....	29.3	36.7	36.7	12.3	41.3	42.7	33.2	6
537	Oderbrucker	.....	22.1	30.0	23.5	.....	.....	.....	25.2	3
529	Princess	.....	32.7	38.5	(2)	.....	.....	.....	35.6	2
530	Chevalier II	.....	36.2	45.8	(2)	.....	.....	.....	41	2
626	California	.....	.....	.....	32.9	12	27.2	26.7	24.7	4
616	Famesh	.....	.....	.....	14.7	3.5	.....	.....	9.1	2
507	Boehme Hooded	.....	.....	.....	27.1	.....	.....	.....	27.1	1
575	White Selection	.....	.....	.....	19.5	.....	.....	.....	19.5	1
78	Sangatsuka [3]	.....	.....	.....	.....	3.4	(4)	.....	.....	1
	Average	35.5	30.5	37	28.7	10	38.4	32	30.3	

[1] Average of 3 check plats.
[2] Destroyed by hail.
[3] For comparison, the yields of the naked varieties are given in bushels of 48 pounds. The actual yield in bushels of 60 pounds, the standard weight, would be one-fifth less.
[4] Yield not recorded.

During four years of this period (1909 to 1911 and 1913), computed yields were figured from the use of check plats. The computed yields are given in Table XVI, with the average actual yields for comparison.

TABLE XVI.—*Computed (annual and average) yields of 16 varieties of barley grown at the Dickinson substation, 1909 to 1913, inclusive,*[1] *compared with the average actual yield for the same years.*

C. I. No.	Variety.	Computed yields per acre (bushels).					Average actual yield.
		1909	1910	1911	1913	Average.	
203	Hanna	46	31	15	28.8	34.6	34
262	Nepal [2]	23	25	14.5	22.5	21.3	19.1
575	Gatami	31.2	38.3	9	28.9	26.9	26.5
863	Manchuria	27.8	23.8	6.1	30.7	21.6	24.2
289	Imperial	38	.....	.....	.....	38	40.4
187	Svanhals	46.8	34.8	8.1	40	32.4	32.3
531	Hannchen	48.7	35.6	15.2	35	33.6	33.6
532	Primus	37	33.2	9.8	40.3	30.1	32.1
537	Oderbrucker	27.6	21.9	.....	.....	24.8	26.8
529	Princess	43.3	.....	.....	.....	43.3	38.5
530	Chevalier II	43.3	.....	.....	.....	43.3	45.8
626	California	.....	31.1	10.3	28.4	23.3	23.9
616	Famesh	.....	19.6	5	.....	12.3	9.1
507	Boehme Hooded	.....	26.9	.....	.....	26.9	27.1
575	White Selection	.....	21	.....	.....	21	19.5
78	Sangatsuka [2]	.....	6.5	.....	.....	6.5	3.4

[1] The check plats in 1912 were not thrashed; therefore, no computed yields are given for that year.
[2] For comparison, the yields of the naked varieties are given in bushels of 48 pounds. The actual yield in bushels of 60 pounds, the standard weight, would be one-fifth less.

Table XV shows that the average actual yield of all varieties grown in 1907 was 35.5 bushels; in 1908, 30.5 bushels; in 1909, 37 bushels; in 1910, 28.7 bushels; in 1911, 10 bushels; in 1912, 38.4 bushels; in 1913, 32 bushels; and for the 7-year period, 30.3 bushels.

SUMMARY OF BARLEY YIELDS.

In summarizing the barley yields the leading varieties of each group represented in the trial were selected. The actual and com-

puted annual and average yields of these varieties are given in Table XVII.

TABLE XVII.—*Annual and average yields of seven standard varieties of barley grown at the Dickinson substation, 1907 to 1913, inclusive.*

[The groups and varieties are arranged according to their actual and computed average yields.]

C. I. No.	Group and variety.	Yields per acre (bushels).									
									Average.		
		1907	1908	1909	1910	1911	1912	1913	6 years, 1907 to 1911 and 1913.	5 years, 1908 to 1911 and 1913.	4 years, 1909 to 1911 and 1913.
	ACTUAL YIELDS.										
	2-rowed hulled:										
531	Hannchen	.....	37.5	43.7	35.4	15.2	39.2	35.0	.....	34.4	33.6
187	Svanhals	.....	39.4	44.9	34.8	8.2	.....	41.1	.....	33.7	32.3
532	Primus	.....	29.3	36.7	36.7	12.3	41.3	42.7	.....	31.5	32.1
203	Hanna	46.8	28.5	39.8	34.8	17.0	46.0	31.4	33.1	30.3	30.8
	6-rowed hulled:										
575	Gatami	36.7	31.4	27.9	34.5	11.9	.....	27.5	28.3	26.6	25.5
863	Manchuria	16.5	27.9	30.2	28.0	7.8	.....	30.6	23.5	24.9	24.2
	6-rowed naked:										
262	Nepal[1]	40.9	22.1	24.1	23.0	8.4	.....	20.9	23.2	19.7	19.1
	COMPUTED YIELDS.										
	2-rowed hulled:										
531	Hannchen	.....	.....	43.7	35.6	15.2	.....	35.0	.....	.....	33.6
187	Svanhals	.....	.....	46.8	34.8	8.1	.....	40.0	.....	.....	32.4
203	Hanna	.....	.....	46.0	31	15.0	.....	28.8	.....	.....	30.2
532	Primus	.....	.....	37.0	33.2	9.8	.....	40.3	.....	.....	30.1
	6-rowed hulled:										
575	Gatami	.....	.....	31.2	33.3	9.0	.....	28.9	.....	.....	26.9
863	Manchuria	.....	.....	27.8	23.8	6.1	.....	30.7	.....	.....	21.6
	6-rowed naked:										
262	Nepal[1]	.....	.....	23.0	25	14.5	.....	22.5	.....	.....	21.3

[1] For comparison, the yield of this naked variety is given in bushels of 48 pounds. The actual yield in bushels of 60 pounds, the standard weight, would be one-fifth less.

Table XVII includes four varieties of 2-rowed hulled, two of 6-rowed hulled, and one of 6-rowed naked barley. The 2-rowed barleys have outyielded the 6-rowed in all the years they have been tested. In a 5-year period (1908 to 1911 and 1913) the two leading 2-rowed varieties have an actual average yield 34 per cent greater than that of the two leading 6-rowed hulled varieties and 75 per cent greater than that of the 6-rowed naked variety. In the four years 1909 to 1911 and 1913, the average actual yield of the leading 2-rowed variety is 32 per cent greater than that of the leading 6-rowed hulled variety and 76 per cent greater than that of the 6-rowed naked variety. The average computed yield of the leading 2-rowed variety for the same period is 25 per cent greater than that of the leading 6-rowed hulled variety and 58 per cent greater than that of the naked variety.

LEADING VARIETIES.

Of all the varieties tested, the 2-rowed varieties Hannchen and Svanhals have proved best adapted to the conditions at Dickinson.

THE 2-ROWED HULLED GROUP.

Hannchen.—The Hannchen barley (C. I. No. 531) was obtained by the United States Department of Agriculture in 1904 from the Swedish Plant-Breeding Association, Svalof, Sweden. This pedigreed variety was originated at Svalof. It is a selection from the

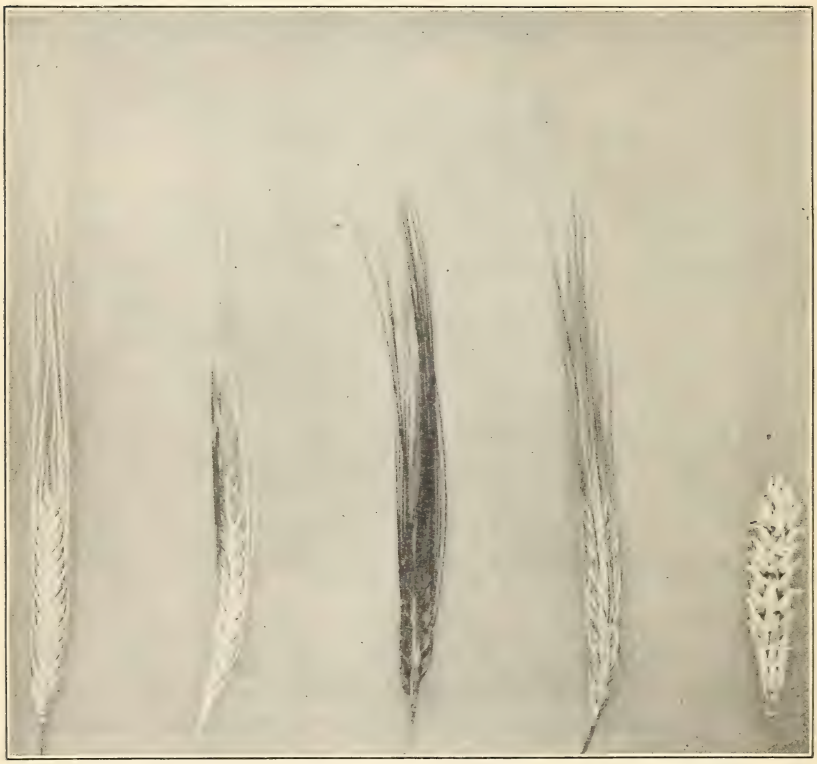


FIG. 6.—Heads of five varieties of barley grown at the Dickinson substation: From left to right—(1) Svanhals, (2) Hannchen, (3) Gatami, (4) Manchuria, and (5) Nepal.

Hanna variety, which was imported from the famous barley district of that name in Mahren, Austria. On account of its relatively small straw and sparse leaf development it can withstand drier weather than most varieties. It has been under trial at Dickinson six years (1908 to 1913) and during that period has given the highest average yields of all varieties tested, 35.2 bushels to the acre. The parent variety, Hanna, during the same period has averaged 32.9 bushels, a gain of 7 per cent in favor of the pedigreed variety.

The Hannchen is considered the best variety for western North Dakota. Besides giving a relatively high yield of grain, it is early in maturing, with strong straw and a high weight per measured bushel. The head is small, but compact. (Fig. 6.) The awns, which are slightly tinged with brown, sometimes fall off at maturity. The kernels are rather long, but of good form, very light colored, and extremely finely wrinkled.

Svanhals.—The Svanhals barley (C. I. No. 187) was obtained by the United States Department of Agriculture from Svalof, Sweden, in 1901. Its name translated into English is Swan Neck, and in some localities it is so known. This variety has broad, dense heads and yellowish white grain.

The Svanhals, like the Hannchen, originated at Svalof. It is a selection from the Diamond, an unfixed product of a cross between a nutant form (probably Chevalier) and Imperial. It is a sister variety of the Primus (C. I. No. 532). The head is broad and arching; hence, the name Swan Neck.

During the 5-year period (1908 to 1911 and 1913) it has been grown at Dickinson it has given an average yield of 33.7 bushels, which is only 2 per cent less than that of Hannchen, the highest yielding variety.

THE 6-ROWED HULLED GROUP.

The 6-rowed varieties of barley have given relatively low yields each year at Dickinson. The leading 6-rowed barley is Gatami (C. I. No. 575), a black variety which in 1907 was obtained by the United States Department of Agriculture from Manchuria. It has outyielded the ordinary 6-rowed varieties each year except 1909, a year of plentiful rainfall. During the six years 1907 to 1911 and 1913 it has outyielded Manchuria (C. I. No. 863), the standard 6-rowed variety, by 20 per cent. During three years, 1908 to 1910, it outyielded Oderbrucker (C. I. No. 537), another 6-rowed variety, by 24 per cent. The Gatami is very early in maturing, and it is probably for this reason that it outyields the other 6-rowed varieties. During the five years 1908 to 1911 and 1913 it has yielded 29 per cent less than Hannchen, the highest yielding 2-rowed variety. The Manchuria barley yielded 38 per cent less than Hannchen in the same period.

THE 6-ROWED NAKED GROUP.

The naked varieties of barley produced comparatively small yields each year at Dickinson. One variety, Nepal (C. I. No. 262), has been continued throughout the trial and has produced an average yield about equal to that of Manchuria. There are several different forms of naked barley. C. I. No. 262 is of the 6-rowed hooded type (fig. 6). Naked varieties are not to be recommended for growing in western North Dakota.

MISCELLANEOUS DATA ON BARLEY.

Some of the more important data on the varieties of barley included in Table XVII are given in Table XVIII. The data were obtained in the same manner as similar data upon the wheat and oat varieties. Table XVIII shows the comparative behavior of the different varieties during the growing season, as well as the yield of straw and grain, weight per bushel, height, and stand.

TABLE XVIII.—*Average miscellaneous data on seven varieties of barley grown at the Dickinson substation for periods of three to seven years (1907 to 1913).*

[Superior index figures indicate the number of years in which the data were obtained when this number is less than the number of years in which the variety was grown. For comparison, the yield of the 6-rowed naked variety is given in bushels of 48 pounds. The actual yield in bushels of 60 pounds, the standard weight, would be one-fifth less.]

C. I. No.	Group and variety.	Number of years grown.	Growth factors (data for 1912 not included).				Average height.	Average stand (plants per acre).	Average actual yield per acre.		Average weight per bushel.
			Average date—		Average time to maturity from—						
			Headed.	Ripe.	Planting.	Heading.			Grain.	Straw.	
					Days.	*Days.*	*In.*		*Bu.*	*Cwt.*	*Lbs.*
	2-rowed common:										
531	Hannchen	6	July 7	Aug. 3	104	27	25	[4] 512,000	35.2	17.4	49.6
187	Svanhals	5	July 5	July 28	104	23	27	[3] 499,000	33.7	16.1	48 4
203	Hanna	7	July 7	Aug. 7	109	31	26	[4] 538,000	34.9	19.8	49 5
532	Primus	6	July 8	Aug. 6	107	29	26	[4] 535,000	33.2	19	49.2
	6-rowed common:										
575	Gatami	6	June 28	July 28	99	30	26	[3] 669,000	28.3	[5] 12.8	49.3
863	Manchuria	6	July 4	Aug. 4	104	31	32	[3] 551,000	23.5	17.4	[5] 48
	6-rowed naked:										
262	Nepal	6	July 2	Aug. 4	104	33	26	[3] 420,000	23.2	17.4	61.8

Table XVIII shows that the barley varieties are all headed by July 8 and ripe a month later, most of them requiring about 104 days from planting to maturity. The Gatami is the earliest variety, requiring only 99 days from planting to maturity. The Hannchen and Svanhals are the earliest 2-rowed varieties. The average height of all varieties is about 27 inches. The Manchuria is the tallest variety, with an average height of 32 inches, while the Hannchen is the shortest, averaging only 25 inches. This is sufficient, however, to permit binding with the ordinary harvesting machinery. Stand notes for a number of years show no definite correlation to yield. The yield of straw is correlated with the length of the growing period, the later varieties producing the largest yield of straw. The highest average weight per measured bushel is 49.6 pounds for the Hannchen variety.

MISCELLANEOUS CEREALS.

A number of other cereal crops have been tested at Dickinson during some of the years covered by this report. They are emmer, winter rye, spring rye, flax, proso, and grain sorghum.

EMMER.

Three varieties of spring emmer were grown during the 3-year period 1907 to 1909. The highest average acre yield was 50.1 bushels for the Yaroslav (C. I. No. 1526). This variety has been continued, but in 1910 and 1912 the crop was destroyed by hail. It has produced an average acre yield of 46.2 bushels for five years (1907 to 1909, 1911, and 1913). The yield of emmer was computed at 40 pounds per bushel. The annual and average yields of grain in pounds per acre, with that of the leading varieties of oats, barley, and wheat, are given in Table XIX.

TABLE XIX.—*Annual and average yields of leading varieties of emmer, oats, barley, and wheat at Dickinson, N. Dak., in 1907 to 1909, 1911, and 1913.*

C. I. No.	Variety.	Yield of grain per acre (pounds).					
		1907	1908	1909	1911	1913	Average.
1526	Yaroslav emmer	1,952	1,180	2,880	1,080	2,150	1,848
656	Early Mountain oats	2,589	1,178	2,880	362	2,154	1,833
203	Hanna barley	2,246	1,368	1,910	816	1,507	1,569
1440	Kubanka wheat	2,160	1,410	2,022	228	1,602	1,484

Table XIX shows that the Yaroslav emmer gave a higher average acre yield of grain for the five years than Early Mountain oats, Hanna barley, or Kubanka wheat. Upon actual food content the yield of wheat is considerably more than the figures indicate, as a certain percentage of the emmer, oats, and barley grain is composed of hull.

RYE.

Tests with both winter and spring rye have been conducted at Dickinson for several years. With the exception of one year (1913) the results are of little or no value, the crop having been destroyed or badly damaged by hail. In 1913 three varieties of winter rye and one variety of spring rye were grown. They were sown on land which had been cropped to corn in 1912. The following acre yields of grain were obtained: Winter rye, North Dakota No. 959 (C. I. No. 175), 31.1 bushels; Von Rümker's green seeded (C. I. No. 174), 21.8 bushels; Von Rümker's yellow seeded (C. I. No. 173), 19.4 bushels; and spring rye (C. I. No. 169), 21.3 bushels. The common winter rye yielded 46 per cent more than the common spring rye.

The two varieties from Dr. von Rümker were obtained from Germany in 1911 by Supt. L. R. Waldron, of the Dickinson substation. They were originated by Dr. K. von Rümker, of Breslau, from a selection from the variety Petkus made in 1899. Reselections were made toward the yellow and green types for the 10 years following. About 35 per cent of each of these varieties winterkilled during the

winter of 1912–13 at Dickinson, which reduced their yield per acre. If later trials show them to be more hardy, they will probably supplant the ordinary rye, as they are far superior in quality. At present North Dakota No. 959 (C. I. No. 175) winter rye is recommended.

OTHER CEREALS.

Varietal tests with flax, proso, and grain sorghum have been conducted in the nursery. Primost flax (Minn. No. 25; C. I. No. 12) and Black Voronezh proso (C. I. No. 27) have also been grown in plat tests. A number of varieties of grain sorghums have been tested at Dickinson, but in only two years (1909 and 1913) have any of the varieties matured seed. In those two years only the early-maturing Manchu Brown kaoliang (C. I. No. 261) entirely ripened. The forage growth of the kaoliang is about half that of corn. Not until earlier varieties than any yet known are produced will this grain-sorghum crop be a profitable one for western North Dakota.

NURSERY EXPERIMENTS.

The nursery experiments at Dickinson during 1908 to 1913, inclusive, afforded an opportunity for growing a larger number of varieties and selections than could be included in the plat experiments. The nursery tests were confined to short rows. These rows were 12 inches apart, the length varying according to the plan of each test. In most of the experiments equal weighed quantities of seed were sown by hand in each row. In some of the experiments a definite number of seeds were sown in each row, placed at definite distances in the row.

The nursery experiments comprise four main groups: (1) Varietal tests (fig. 7); (2) pure-line selections, including head rows and increase rows; (3) crosses; and (4) miscellaneous, including date, rate, and depth of planting tests, seed treatment, etc. Table XX shows the number of plantings each year in the different lines of work. Each of these groups will be discussed separately.

TABLE XX.—*Number of plantings in the cereal nursery at Dickinson, N. Dak., from 1908 to 1913, inclusive.*

Cereal plantings.	1908	1909	1910	1911	1912	1913
Spring nursery:						
Varietal tests	211	261	387	372	438	481
Pure-line selections	231	264	340	205	414	489
Crosses	3	40	164	287	76	8
Miscellaneous	63	.....	65	102	22	180
Fall nursery:						
Varietal tests	.....	.....	7	.....	10	15
Pure-line selections	.....	.....	100	370	297	335
Crosses	.....	.....	.....	226	429	116
Miscellaneous	.....	.....	.....	.....	.....	5
Total	314	315	1,063	1,562	1,686	1,629

VARIETAL TESTS.

A much larger number of varieties is tested each year in the nursery than in the field plats. The new varieties which are continually being introduced and originated are here given their first trial. The land used is alternately cropped and fallowed. The seed is sown by hand in a furrow about 3 inches in depth, which has been opened with a wheel hoe. It is then covered by a special attachment upon the same tool. The rows are 17 feet long and 12 inches apart. Every third row is planted to the same variety, as a check. Careful notes are taken throughout the season on the comparative behavior of the different varieties. At harvest time each row is cut (a part of the row is pulled) separately, labeled, and the

FIG. 7.—General view of the cereal nursery at the Dickinson substation in 1913.

heads covered with paper sacks to prevent mixture or damage by birds. The total weight of each row and the total weight of grain per row are obtained at thrashing time. In addition, the following notes are taken on 25 plants from each lot: Height of plant, length of head, number of culms per plant, number of heads per plant, total weight of plants, and weight of grain. These notes for a series of years give a rather accurate analysis of each variety. The correlation of the different characters, with yield, is the primary object of this analysis.

The weight of grain per row gives the relative yielding power of the different varieties. Computed yields are determined from the use of the check rows. New and untried varieties in this way are compared with standard and better known varieties. Any variety producing a relatively high yield for several years is increased and

included in the regular varietal trial. All varieties are continued in the nursery at least three years before being discarded.

PURE-LINE SELECTIONS.

Pure-line selections have been made of several unpedigreed cereal varieties, which have proved well adapted to the conditions at Dickinson. Typical and sometimes unusual heads of the variety are selected in the field. The length of these heads and the number of kernels each contains are usually determined and the heads photographed. Twenty kernels from each head are planted in rows 5 feet long and 12 inches apart. The kernels are placed 3 inches apart in the row. Notes are taken throughout the growing season upon the comparative behavior of the different selections. Each row is harvested and thrashed separately, and the seed is used the following year for planting in the pure-line selection nursery, where they are more carefully studied and tested for yield. The pure-line selection nursery is similar to the varietal nursery, the rows being 17 feet long and 12 inches apart. Equal weighed quantities of seed are sown in each row. Notes similar to those taken on the varieties are taken on the pure lines. Check rows sown with the unselected parent variety are used, and any improvement which is made is thus easily determined. This nursery is continued from year to year. All pure lines are usually grown three years before any are discarded. The highest yielding strains are then planted in larger plats of any convenient size, to increase the seed. Finally those pure strains that have proved superior to the parent, as well as to other pure lines, are introduced into the plat varietal trials.

From such a large number of selections as there are at Dickinson a great mass of data has naturally been accumulated. The limits of this bulletin prevent its presentation here. As previously mentioned, a strain of Kubanka durum wheat, Kubanka No. 8 (C. I. No. 4063), and a strain of Early Mountain oats, Early Mountain No. 2 (C. I. No. 656), have been developed which have proved superior to the original varieties. In Table XXI some of the results obtained in 1913 in improving the yield and the milling and baking qualities of Ghirka wheat are shown. This table shows the possibilities of improvement and also the possible increase or decrease in quality and yield of grain that may be obtained from pure-line selections.

TABLE XXI.—*Results of milling and baking tests and yield of grain per acre of unselected Ghirka wheat and of five pure-line selections from it grown at Dickinson, N. Dak., in 1913.*

Variety.	Actual yield per acre.	Cleaned weight per bushel.	Protein in wheat (N.×5.7).	Yield of flour.	Loss in milling.	Volume of loaf.	Color.	Texture.
	Bushels.	*Pounds.*	*Per cent.*	*Per cent.*	*Per cent.*	*C. c.*	*Pr. ct.*	*Pr. ct.*
Ghirka, unselected	30	64.3	13.88	69.6	5.51	2,011	92.5	91.5
Ghirka No. 4	35.6	65	14.36	71.2	3.35	2,450	96	94
Ghirka No. 19	27.7	64	15.28	69.1	4.5	2,265	96	93
Ghirka No. 29	33.2	63.5	15.62	67.5	7.1	1,790	94	86
Ghirka No. 31	38	65.5	15.28	70.1	4.17	1,985	90	92
Ghirka No. 66	35.2	65	14.76	72.4	1.46	2,097	95	93.5

CROSSES.

Attempts to originate new and better cereal varieties by means of hybridization have been made at Dickinson. Work has been done with both natural and artificial crosses. It is probable that crosses occur naturally in the cereal crops, especially wheat, more often than is usually supposed. A number of field crosses of wheat selected from the varietal plats have been planted in the nursery at Dickinson. These have broken up in the next generation, and the many different types have been replanted. Several pure lines have been segregated, but none have been of any economic value. Artificial crosses have been made with both spring and winter wheat and with barley. With spring wheat the object of the work is to increase the milling qualities of the Ghirka variety by crossing it with Red Fife and other good milling wheats and still to retain its earliness and high yield. The barley crosses have been made between Hannchen and several other varieties, the purpose being to obtain earlier and taller varieties.

Most of the crosses, however, have been made with winter wheat, with the object of increasing their hardiness or winter resistance. The theory that a part of the offspring of crosses between two medium-hardy strains of one variety or of different varieties will exceed the parents in winter resistance if they follow the ordinary Mendelian laws in respect to this character, as they do with other characters, was developed independently by Nilsson-Ehle[1] and by Waldron.[2] This work has been under way at Dickinson for three years. In 1911 and 1912 crosses were made on over 3,000 individual wheat flowers. In 1913 about 1,300 individual crosses were made. The seeds from these crosses are planted 3 inches apart in rows 12 inches apart. Twenty seeds of each parent are planted in rows on either side of the crossed

[1] Nilsson-Ehle, Herman. Kreuzungsuntersuchungen an Hafer und Weizen. *In* Lunds Univ. Årsskr., n. f. afd. 2, bd. 5, no. 2, 122 p., 1909.

[2] Waldron, L. R. Increase in hardiness. *In* N. Dak. Agr. Exp. Sta., Dickinson Sub-Exp. Sta., 3d Ann. Rpt., p. 33, 1910.

Waldron, L. R. Breeding certain field-crop plants in the cold northwest. *In* Amer. Breeders' Assoc. Ann. Rpt. 8, 1911, p. 434, 1912.

grains. In the F_1 generation the plants are covered with a light straw mulch to prevent winterkilling. In the F_2 generation they are planted in the regular nursery row at the usual rate and tested for winter resistance. The parent strains are planted as checks. This work was retarded by the hailstorm in July, 1912, when practically all of the crosses made in that year were destroyed. No conclusions can be drawn from the work already done, although there are now in existence several apparently hardy strains.

In this connection it is of interest to note that Nilsson-Ehle[1] has concluded that the winter-resistant character is transmitted as are other characters, that crossing results in segregation of gradations of this character, and that it seems to be the result of a variety of combinations of many Mendelian factors.

MISCELLANEOUS TESTS.

Several cultural tests have been under way in the nursery with the different varieties of cereals, but the results of these tests are not germane to the purposes of this bulletin.

SUMMARY.

Cooperative experiments with cereals have been conducted at the Dickinson (N. Dak.) substation since 1907. The testing and improvement of cereal varieties have constituted the major part of the work.

The substation is located near the center of Stark County, in southwestern North Dakota, at an elevation of approximately 2,500 feet.

The average annual rainfall at Dickinson for the 22 years from 1892 to 1913, inclusive, was 15.46 inches, of which 70.1 per cent fell during the months from April to August, inclusive, the growing season at Dickinson. The average precipitation for the growing season for the years 1907 to 1913, the period during which cooperative experiments with cereals have been conducted, was 11.54 inches. The average evaporation from a free water surface during the same period was 29.524 inches.

The average wind velocity per hour during the months from May to August, inclusive, for the 6 years from 1908 to 1913 was 7 miles. The average mean temperature for these months was 57° F.; the average length of the frost-free period, 99 days. The maximum frost-free period was in 1909, from May 17 to September 14, 120 days. The latest date at which frost has occurred in the spring in the seven years was June 5; the earliest frost in the fall was on August 19.

[1] Nilsson-Ehle, Herman. Zur Kenntnis der Erblichkeitsverhältnisse der Eigenschaft Winterfestigkeit beim Weizen. *In* Ztschr. Pflanzenzucht., Bd. 1, Heft 1, p. 3–12, 1912.

The primary object of the experimental work has been to determine the relative yielding power of different varieties of cereals, to discover varieties better than those ordinarily grown, and to improve the yield of the leading varieties.

The usual size of the plats on which the tests were conducted was one-tenth of an acre. Check plats were used to determine the soil variations.

The varietal tests have included 53 varieties and strains of spring wheat, 38 of spring oats, 16 of spring barley, and a number of varieties of winter wheat, winter and spring rye, and emmer.

Spring varieties of all the cereals, except rye, are better adapted than winter varieties.

The average yield of all varieties of spring wheat for the six years 1907 to 1911 and 1913 was 22 bushels.

Of the spring-wheat varieties, the durum group has given the best yields. The fifes and the bearded fifes yielded practically the same, ranking next to the durums in yield. The bluestem group, commonly grown in North Dakota, is comparatively low in yield.

The Kubanka is the leading variety of durum wheat. The Ghirka is the leading variety of fife wheat.

Spring wheat is usually in head at Dickinson by the middle of July and is ripe by the middle of August. The average date of heading and the average date of ripening varied widely with different varieties. The Ghirka, Bearded Fife, and Marquis are early varieties. This character is important for drought-resistant or drought-escaping cereals.

The yield of straw and the weight per bushel of the bearded fife varieties are less than those of the durums, but more than of the fifes and bluestems.

Milling and baking tests for 1911 and 1913 show that the different groups of wheat rank as follows in yield of straight flour: Bluestem, durum, bearded fife, and fife. The durum variety Kubanka No. 8, a pure-line selection, gave the highest average percentage of flour. In volume of loaf the groups rank as follows: Bluestem, fife, bearded fife, and durum. The fife variety White Fife gave the highest average loaf volume of any variety.

The yield of winter wheat has been low as compared with spring wheat, the stand in all seasons being greatly reduced by winter-killing.

The average yield of all varieties of oats for the seven years 1907 to 1913 was 47.7 bushels. The groups of oats rank in yield in the following order: Medium early, medium late, early, and late.

The Early Mountain variety has given the highest actual yields for the seven years, 54.1 bushels. On 5-year and 4-year averages the

Golden Rain has given the highest average yields. The Victory oat has yielded next in order.

The average length of time from planting to maturity varies from 103 days for the Kherson and Sixty-Day varieties of oats to 128 days for the White Russian. The average date of heading for the varieties is July 11 and the average date of ripening August 13.

The average yield of all varieties of barley for the seven years from 1907 to 1913 was 30.3 bushels.

Two pedigreed 2-rowed varieties of barley, Hannchen and Svanhals, have proved best adapted to the conditions at Dickinson. These varieties have outyielded the commonly grown 6-rowed varieties, Manchuria and Oderbrucker, from 36 to 55 per cent during the years grown. The naked varieties of barley have produced comparatively small yields each year at Dickinson, averaging about the same as the Manchuria.

The Yaroslav emmer has given a higher average acre yield of grain for the five years 1907 to 1911 and 1913 than Early Mountain oats, Hanna barley, or Kubanka wheat.

The cereal nursery has afforded an opportunity for growing a larger number of varieties and selections than could be included in field plats. The tests in the nursery are confined to short rows. Here new varieties are compared with standard and better known sorts. A large number of pure-line selections from several unpedigreed varieties which have proved well adapted at Dickinson are being tested in the nursery. Considerable crossing has been done in an attempt to originate new and better varieties. Most of the crosses have been made with winter wheat, with the object of increasing their winter resistance.

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